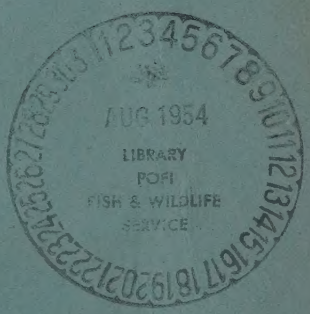
Bulletin of Marine Science

of the

Gulf and Caribbean

p. 110
12 D-15

VOLUME 4
NUMBER 2



Published by the University of Miami Press
JUNE, 1954 • CORAL GABLES, FLORIDA, U.S.A.

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OF THE GULF AND CARIBBEAN

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BULLETIN OF MARINE SCIENCE
OF THE GULF AND CARIBBEAN

VOLUME 4 1954 NUMBER 2

THE RELATION OF TOTAL RAINFALL OF THE STATE AND CATCH OF THE MARINE SHRIMP (*PENAEUS SETIFERUS*) IN TEXAS WATERS

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ABSTRACT

The catch of white shrimp, *Penaeus setiferus,* along the Texas Coast from 1927 to 1952, inclusive, shows a strong statistical correlation with the total rainfall of the State. The young shrimp grow up in low salinity, estuarine areas and there are some indications that the correlation depends upon salinity *per se* rather than other factors, such as nutrient salts brought in from land. There is a lag effect in the shrimp catch-rainfall correlation in that the catch is correlated with rainfall of the previous year and the year before that. There are some indications that this may be due in part to a lag in the rise and fall of salinity of bay and offshore waters following wet and dry spells; it may also be due in part to the life history of the shrimp, for part of the population lives over from one year to the next. General inspection indicates that other possible factors influencing the shrimp catch such as technological improvements, the shrimp price, general price index and economic cycles, are not correlated with the white shrimp catch during this period, whether or not trends are removed. These matters were not statistically analyzed.

INTRODUCTION

The white shrimp, *P. setiferus,* of the Gulf and South Atlantic Coasts of the United States spawns in the open sea and undergoes a complicated larval history as the young move slowly toward the bays. The juveniles enter the estuarine waters where they grow up, later returning to the sea. This type of life history is necessary for the white shrimp and postlarvae that fail to enter inside waters perish. The young go into waters of low salinities and are quite common at 4.9 *per mille* and less (Gunter, 1950, p. 22) and Gunter (p. 43) termed them "practically euryhalin." This term applies, however, only to the

species as a whole and it has been shown (*op. cit.*, p. 21) that there is a direct relationship between salinity and size, due to the progressive movement of shrimp back towards the sea as they become larger. Thus the largest shrimp are never found in low salinities. Further indication of the fundamental connection between the white shrimp and low salinity is shown by the fact that the vast estuarine area around the mouth of the Mississippi River is the most productive shrimping grounds on earth; for many years the Louisiana annual shrimp catch equalled that of the remainder of the continent.

Thus, when the white shrimp catch began to fall in Louisiana in 1946 and Texas in 1947, thought naturally turned to a possible connection with the drouth and the possibility was recognized by some shrimp fishermen. The first printed reference to this suggestion is that of Burkenroad (1951, p. 209). One of us (H. H.) began collecting data on coastal rainfall and the shrimp catch in the fall of 1951. It became clear that the total rainfall of the state would have to be used, since Texas is practically a geographic unit in this respect; and the writers published an analysis (Hildebrand and Gunter, 1953) showing a high correlation between the Texas catch of white shrimp and the rainfall of the State since 1937, when high level shrimp catches on the Texas Coast began. There was one previous year, 1934, with a high catch, but, since there were no data for 1933 and 1935, the year 1937 was selected as a starting point. This beginning was chosen because of the assumption that any possible correlation of shrimp catch and rainfall would be more apparent as the catch approached the maximum available, than in the previous years of low catches when presumably the stock was not so heavily fished. This seems to be a logical assumption. Nevertheless, the analysis is subject to the criticism that the selection of years was arbitrary, especially since one year of high production was not included. For that reason we propose to approach the problem here by utilizing the catch of all years since the Texas fishery was established in 1927.

Texas White Shrimp Catch and Total Rainfall, 1927-1952

The total catch and rainfall are shown in Table 1. These data are all taken from reports of the Fish and Wildlife Service and the Texas Game and Fish Commission, except for those of later years (1947 on) which are from the Fishery Market News Service, and the two estimated years shown in parentheses. The catches for 1948 and 1949

are based on personally gathered statistics from dealers along the coast. Thus they are roughly comparable to similar statistics given out by official agencies. The 1933-1935 estimates fall in a different category. The Texas Game, Fish and Oyster Commission did not collect statistics during that period and collection of Federal fishery statistics were curtailed by lack of funds. Therefore, the writers made an "educated" guess based upon the general catches of years before and after and the statements in Game, Fish and Oyster Commission Annual Reports on the relative catch compared to other years. It seems proper to say that these estimates were made some six months before any calculations were made and with the agreement of a verbal critic of our original (1953) paper on this subject. They are probably as accurate estimates as can be made now, some twenty years later.

TABLE 1

TOTAL WHITE SHRIMP CATCH, IN MILLIONS OF POUNDS, AND THE ANNUAL AVERAGE RAINFALL, IN INCHES, FOR THE STATE OF TEXAS, 1927-1952. (FOR FULL EXPLANATION SEE TEXT)

Year	*Shrimp catch (Millions of pounds)*	*Rainfall (Inches)*	*Year*	*Shrimp catch (Millions of pounds)*	*Rainfall (Inches)*
1927	11.8	27.8	1940	14.8	35.0
1928	7.8	29.0	1941	19.3	43.5
1929	9.4	31.2	1942	21.8	33.2
1930	10.2	29.7	1943	22.9	25.4
1931	13.8	29.3	1944	18.6	36.2
1932	9.2	34.1	1945	15.7	33.4
1933	(9.5)	26.0	1946	21.5	38.0
1934	16.4	26.8	1947	21.8	26.8
1935	(9.0)	37.5	1948	14.9	24.2
1936	10.0	30.7	1949	12.0	34.3
1937	16.9	26.8	1950	12.7	25.2
1938	16.4	27.2	1951	7.3	21.1
1939	11.2	24.7	1952	5.3	22.9

Table 2 shows the correlations of the shrimp catch with rainfall and the levels of significance, with various combinations of years. The correlation increases backward with the years to the two previous years before the catch. Catch of the year with rainfall of the year is not necessarily correlated, since part of the catch comes in months prior to the rainfall. Two year running averages of catch with two-year running averages of rainfall, one year before, and three-year running averages of catch and rainfall give highly significant correlations. Annual catches of shrimp with two-year running averages of

rain one year before, and with three year running averages of rainfall, including that of the year, also give significant correlations.

TABLE 2

CORRELATIONS AND SIGNIFICANCE LEVELS BETWEEN ANNUAL WHITE SHRIMP CATCH AND ANNUAL RAINFALL OF THE STATE OF TEXAS, 1927-1952, INCLUSIVE.

Years Compared	*r*	*Significance, 5% level*	*Significance, 1% level*
Same Years	0.304	0.388	0.496
Year's catch and previous year's rain, viz. 1930 catch and 1929 rain, etc.	0.469	0.388	0.496
Year's catch and rain 2 years before, viz. 1930 catch and 1928 rain, etc.	0.491	0.388	0.496
Catch with rain of year and year before, viz. 1930 catch with 1930 and 1929 rain, etc.	0.496	0.388	0.496
Catch with rain of the 2 previous years, viz. 1930 catch with 1928 and 1929 rain, etc.	0.663	0.388	0.496
Two year running average of catch with 2 years running average of rain one year before, viz. 1929-30 catch with 1928-29 rain, etc.	0.521	0.396	0.505
Three year running averages of shrimp and rain, same years.	0.586	0.404	0.515
Year catch of shrimp with 3 year running average of rainfall (same year and the 2 previous years).	0.703	0.388	0.496

Table 3 shows the correlations and significances when the fitted years 1933 and 1935 were not included in the calculations. The numerical correlation on the whole increased slightly, but so did the level of significance, and the inclusion or exclusion of these years makes very little difference in the correlation of shrimp catch and rainfall in Texas from 1927 to 1952, inclusive.

It seems clear that the catch of the marine shrimp, *Penaeus setiferus*, in Texas waters is correlated with the rainfall of the State from 1927 to 1952, inclusive, a period of 26 years, and more specifically with rainfall of the immediately preceding years. These results verify the conclusions of Hildebrand and Gunter (1953) and are more palatable because they cover the whole series of data available.

DISCUSSION

A question immediately arising is whether or not this correlation is real or fortuitous, because of unseen relations with technical im-

TABLE 3

CORRELATIONS AND SIGNIFICANCE LEVELS OF SHRIMP CATCH AND RAINFALL FROM 1937-1952, INCLUSIVE, WITH THE FITTED YEARS 1933 AND 1935 EXCLUDED. (SEE TEXT AND TABLE 2 FOR FURTHER EXPLANATION).

Years Compared	*r*	*Significance, 5% level*	*Significance, 1% level*
Catch with rain of year and year before.	0.472	0.404	0.515
Catch with rain of one and two years before.	0.699	0.404	0.515
Catch, 2 year running average with 2 year running average of rain one year before.	0.593	0.433	0.549
Three year running averages shrimp and rain, same years.	0.621	0.456	0.575
Annual catch and three year running averages of rainfall, same year and 2 previous years.	0.804	0.404	0.515

provements, natural growth of the fishery, or the economic cycle. It should be noted that the time over which the correlation has held covered a period of high business activity, followed by a depression, slight recovery, recession, a war and high economic activity ever since. The price index was low in the beginning and increased rather steadily as the catch went up, but any correlation between price and catch falls off sharply after 1947. However, the catch increased only 71 per cent, comparing the 1927-1936 period with the high level production of 1937 to 1947, while prices have risen from 5¢ to $1.25 per pound. If the economic index were related to shrimp prices, the value fluctuation in shrimp would doubtless be less but in any case any possible correlation comes to naught after 1947. Similarly, technological improvements in fishing have continued as the catch fell. By removing the trend of greater production, as salesmanship increased the market for shrimp, it appears that the correlation of catch with rainfall will, if anything, be increased from the early years to the mid-1940's, but here the trend turns downward and it seems scarcely legitimate to use a varying trend line over a long series of data, and it is better to use the raw data.

Thus general inspection shows that correlations of price, economic index, increased technical improvements, etc. with the white shrimp catch do not hold up and it appears to us profitless to attempt them. For instance in 1952 shrimp prices to the fisherman rose to $1.25

per pound, the highest in history, while the white shrimp production of Texas fell to 5.3 million pounds, the lowest since the fishery began except for the initial years when the otter trawl was being introduced.

Another consideration arising is the possibility that the decline since 1947 is due to overfishing. First we would have to dismiss the coincidence that overfishing coincided with what has been termed the greatest drouth since Columbus discovered America. The shrimp catch held up at what appeared to be a maximum for many years after the catch per trawl had considerably declined (Hildebrand and Gunter, 1953, p. 153). It was suggested that the shrimp fishery is one where the maximum available may be equivalent to the maximum equilibrium yield (*op. cit.*, p. 154). Additionally, shrimp are relatively short-lived, a little over a year for practical purposes, and they serve as food for almost all large animals which live in the sea. The abundance of shrimp in stomachs of marine fishes led Burkenroad (1951, p. 185) to assume that the annual take by fish is on the order of the catch by man.

It thus appears that the most reasonable explanation of the real long term fluctuation of the Texas white shrimp catch is its relation to rainfall. The writers are not statisticians and one of us (G. G.) has long followed a personal predilection of using statistics solely as a measuring device, for relationships which are obvious by other means, because of the belief that if one must search for relationships by means of statistics there is not much present. The point is mentioned because the first paper (*op. cit.*) calls attention to the high and low shrimp catch and blocks of dry and wet years, and it was first written in that form. The calculation of coefficients of correlation was an afterthought.

The year 1934 is remembered by the older fishermen as the year they "bogged down" in shrimp. The catches per boat were very high and there are indications from newspaper reports, and from Game, Fish and Oyster Commission Reports, as well as from memory of the fishermen, that this was the year of peak abundance of shrimp on the Texas Coast. There is no indication from the State rainfall of a correlation. However, three hurricanes struck the Texas Coast in 1933 and two in 1934 (Schlesselman, 1945). This seems to be a record for a two year period. These produced heavy local rainfall along the coast. Such local rainfall does not wash in great amounts of nutrients salts from land but such local rains do markedly lower bay salinities; at times they even raise water levels in the relatively landlocked Texas

bays. The known facts about the Laguna Madre further indicate that salinity and not nutrient salts are the limiting factor in shrimp production. This coastal lagoon has no rivers draining into it and the connections with other water bodies at both ends are small. Salinities become extremely high in the central portions, often being twice as high as sea water. Shrimp do not raise there and are normally completely absent from the central portions. Yet this lagoon is fertile and produces as much fish as the remaining part (three-fourths) of the Texas Coast. During 1941, a very wet year, sheet drainage from land and direct rainfall lowered the salinity of the Laguna considerably. Fishermen reported that shrimp came out of it and good shrimping was had at the upper mouth of the Laguna. Such local rainfall and drainage would more likely lower the concentration of nutrients in the Laguna by dilution and flushing rather than increase them. Yet this was one of the rare periods of shrimp production in the Laguna.

The final question concerns the reason for the lag in the relation of shrimp catch to rainfall, i. e. the catch relation to rainfall of the previous years. Possibly this lag is due to enrichment of the bays by nutritive salts from land and the effects of a chain of ecological events. However, in view of the rapid effects of pond fertilization and their rather quick cessation, the apparent effects of nearby coastal rains, which would add little nutrients to the bays, and the known relationships of shrimp to salinity mentioned in the introduction, it seems that the simplest and most probable connection of shrimp production and rainfall is through salinity of the bays, which is governed by rainfall.

In view of the general paucity of long term hydrographic work in estuarine areas over the world, it goes without saying that salinity data, adequate for relation to the shrimp catch, even in one bay let alone the whole Texas coast for the 26 year period, is completely absent. For that reason the writers have utilized rainfall, which is one step removed from the probable effective factor, salinity, in this analysis.

The Texas bay area is approximately 3500 square miles and the off-shore Gulf waters inhabited by the white shrimp (roughly out to 18 fathoms) cover about 3,000 more. This is covered by approximately 50 cubic miles of water. During 1941 and 1942 the average Gulf bottom salinities at one and five miles off Aransas Pass, a dry part of the coast, averaged 31.5 *per mille* as compared to full Gulf

water at 36.0 (Gunter, 1945, p. 125). In Aransas and Copano bays the average salinities were 20.5 and 9.1 *per mille,* respectively. During the drouth Copano Bay water rose to a salinity equalling sea water, and even in 1953, after the drouth was partly broken, the salinity of Corpus Christi Bay equalled that of sea water. Obviously, these larger water masses do not change salinity overnight, either with rain or the lack of it. There would be some lag caused by the land itself, since a dry land would absorb more water following drouths and conversely the effect of drouths on well watered land would not show immediately. Thus the lag in shrimp production as related to rainfall may reflect a lag in the salinity change of the inshore waters following rains.

It takes approximately three years for fish life along the Texas coast to recover from the effects of hard cold waves and it has been tacitly assumed that this was due to time it takes the new crops of fish to grow up (Gunter, 1952, p. 63). No such relation holds for shrimp, however, for they grow up in a year and less.[1] However, some shrimp live over from one year to the other. This in itself would produce some lag effect.

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[1]Gunter (1950, pp. 18-21) suggested, on the basis of his data, that small shrimp come into the catch in two peaks in the warm months and grow at the rate of one mm a day or more. Thus the first crop attains adult size before the end of the season, while the second group becomes adult the following spring. This theory of the shrimp life history explains the anomalies which have puzzled shrimp workers for 25 years and it hinges on the fast growth rate, which Gunter thought was a new idea at the time and attributed (*op. cit.* p. 20) to a colleague. However, it is now clear that Viosca's work led him to originate this idea over thirty years ago (Viosca, 1953). The first printed reference is in Tulian (Fourth Biennial Report, Dept. of Conservation, State of Louisiana 1920, p. 11-12), who quoted Viosca's observation that it seems to take a shrimp six months to reach maturity.

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METACERCARIA OWREAE N. SP., AN UNUSUAL TREMATODE LARVA FROM FLORIDA CURRENT CHAETOGNATHS[1]

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ABSTRACT

Metacercaria owreae n. sp., a new larval trematode, has been described from *Sagitta enflata* Grassi, *S. hexaptera* d'Orbigny and *S. lyra* Krohn. This species appears to differ from other larval or adult trematodes in having the digestive caeca extending into a pair of posterior appendages.

Busch (1851) reported three larval trematodes from *Sagitta cephaloptera* (= *Spadella cephaloptera*) collected near Trieste. He identified one species as *Distomum papillosum* Diesing (= *D. beroë* Will), but considered the others to be new and gave them the names *D. fimbriatum* and *D. crassicaudatum*. Leuckart and Pagenstecher (1858) very briefly mentioned and figured, but did not name, a monostome and distome from *Sagitta germanica* (= *S. setosa* Müller) collected at Helgoland. Sinitsin (1911) described three larval trematodes, *Adolescaria progastrica, A. metagastrica* and *A. appendiculata,* from *Sagitta* collected from the Black Sea. Lebour (1917) found the larvae of *Derogenes varicus* (O. F. Müller) and *Pharyngora bacillaris* (Molin) in *Sagitta bipunctata* Q. and G. from Plymouth Sound. According to Dollfus (1923), *Aphanurus* larvae were found in *Sagitta* from the Gulf of Trieste and at Naples by Steur and Monticelli. Linton (1927) described, but did not name, two adult distomes from a specimen of *Sagitta elegans*. Steuer (1928) recorded a larval hemiurid (*Hemiurus rugosus* Looss?) from *Sagitta* of the Mediterranean Sea.

Several species of larval trematodes occur in the chaetognaths of the Florida Current. One of the most common forms is a larval *Derogenes,* probably *D. varicus* (O. F. Müller). It was found in the body cavities of *Sagitta enflata* Grassi and *S. serratodentata* Krohn.

In 1952, the present author figured a larval trematode under the name *Cercaria D*. This larva was found free in a plankton haul. During the past three years, Mrs. Harding Owre of the Marine Laboratory, University of Miami, found this parasite 8 times out of 5767 specimens of *Sagitta enflata, S. hexaptera* and *S. lyra*. The description of this species is based on these 8 specimens which Mrs. Owre kindly allowed me to examine.

[1]Contribution No. 118 from the Marine Laboratory, University of Miami.

This material was obtained from plankton hauls taken through a joint program of the Marine Laboratory of the University of Miami and the National Geographic Society.

Methods

All material was obtained from plankton hauls preserved with formalin. Measurements were made from specimens stained with borax carmine and mounted in Canada balsam. Serial sections (5 μ) were stained with Ehrlich's haematoxylin and eosin and mounted in Canada balsam or cristalite.

Metacercaria owreae n. sp.

(Figs. 1-3)

The body of this marine distome is ovoid, tapering somewhat at the anterior end. The cuticle is densely covered with circular furrows, becoming slightly deeper and more distinct posteriorly. There is a subcuticular layer, except at the extreme anterior end of the body; near the oral sucker, the layer separates from the cuticle and runs medially anterior to the oral sucker (Fig. 1). There are no muscle fibers visible in the anterior part of this subcuticular layer, but at the level of the ventral sucker muscle fibers appear and become more prominent posteriorly. Protruding from an opening in the posterior end of the body is a pair of appendages (Fig. 1-3) covered with a smooth cuticle.

The subterminal oral sucker is followed by a wide pharynx. The oesophagus is short, bifurcating almost immediately into the intestinal caeca. These tortuous caeca extend forward for a short distance before curving and running posteriorly, bulging just behind the ventral sucker and narrowing at the posterior end of the body where they enter the posterior appendages; they expand again after entering the appendages. Situated slightly anterior to the center of the body is a large ventral sucker. Reproductive organs were not developed, and the excretory system was not visible. Measurements (in microns) of the smallest specimen are: body length 320; body width 152; oral sucker width 96; ventral sucker width 112; right appendage length 160; right appendage width 80; left appendage length 160; left appendage width 80; measurements (in microns) of the largest specimens are: body length 720; body width 464; oral sucker width 160; pharynx width 110; ventral sucker width 208; right appendage length 384; right appendage width 80; left appendage length 256; left appendage width 80.

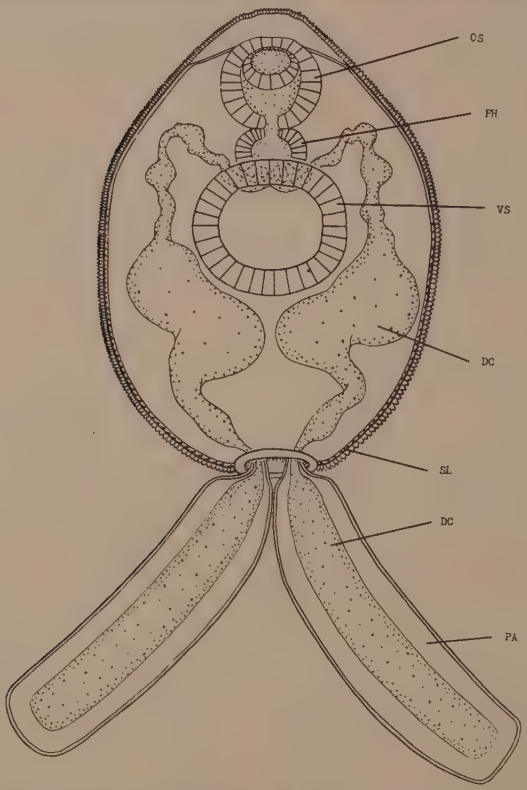

FIGURE 1. Semi-diagrammatic drawing of *Metacercaria owreae* from ventral side, to show general morphology. DC, digestive caecum; OS, oral sucker; PA, posterior appendage; PH, pharynx; SL, subcuticular layer; VS, ventral sucker.

Hosts: Sagitta enflata Grassi; *S. hexaptera* d'Orbigny; *S. lyra* Krohn.

Habitat: Trunk coelom.

Locality: Florida Current (east of Miami).

Incidence of infection: 0.14% (*S. enflata* 0.09%; *S. hexaptera* 0.14%; *S. lyra* 1.15%).

Superficially this larva appears to be a furcocercous cercaria, but total mounts stained with borax carmine give the appearance that the intestinal caeca enter the posterior appendages. Serial sections (5μ) of

FIGURE 2. Photomicrograph of *M. owreae* (x36) in the body cavity of *Sagitta enflata* Grassi.

two specimens, one cut transversely and one longitudinally, showed this to be true. Thus, these appendages do not seem to be furcae at all or tail structures in the usual sense. In so far as the author is aware, *Metacercaria owreae* differs from other adult or larval trematodes in having a pair of posterior appendages into which the digestive caeca extend.

The date, depth (in meters), time and locality of the plankton hauls in which eight specimens of *Metacercaria owreae* used in this study were found are summarized in Table 1.

FIGURE 3. Photomicrograph of *M. owreae* (x115) from ventral side.

TABLE 1

Parasite	*Date*	*Depth* (m)	*Time*	*Locality* (ca.)
1	3/VII/50	0-25	2200	25° 44′ N., 79° 55′ W.
2	22/VIII/50	16	1030	"
3	13/X/50	32	0930	"
4	13/X/50	25-75	0947	"
5	10/XI/50	50	1400	"
6	5/VI/51	300-350	1320	"
7	14/VIII/51	55	1100	"
8	4/II/52	95	1153	"

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A STUDY OF CERTAIN CHROMOGENIC BACTERIA ISOLATED FROM "RED TIDE" WATER WITH A DESCRIPTION OF A NEW SPECIES.[1]

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ABSTRACT

Experiments performed with a chromogenic bacterium designated as *Flavobacterium piscicida* (sp. nov.) indicates that this organism in pure culture is capable of killing certain fishes under laboratory conditions. This organism was isolated from a fish kill in which no dinoflagellate bloom was present. Similar bacteria have been isolated from Red Tide outbreaks attributed to *Gymnodinium brevis* and from *G. brevis* cultures at the Marine Laboratory and indicates the possibility that a bacterium may be associated with fish deaths under natural conditions. Further investigation is warranted as to the possible relationship of bacteria and dinoflagellates in causing the phenomenon known as "Red Tide."

INTRODUCTION

"Red Tide" was first studied by the Marine Laboratory of the University of Miami at the time of the outbreak of mass mortality of fishes on the west coast of Florida from November, 1946, to January, 1947. Examination of this water by the Marine Laboratory revealed the presence of the phytoplankter, *Gymnodinium brevis*. This organism was present in numbers exceeding normal bloom proportions and was believed to be the etiologic agent for the fish mortality observed at this time. Other occurrences of fish kills elsewhere have revealed the presence of other organisms similar to *Gymnodinium brevis*, and experiments with these organisms indicated that they were capable of producing lethal effects on fishes in the laboratory. Plankton blooms similar to those which produce Red Tides are relatively common in the coastal waters of the world (Brongersma-Sanders, 1948). These outbreaks are not always accompanied by fish mortality. Heavy fish mortality seems to be commonly associated with certain species of dinoflagellates while others appear to be non-toxic.

On May 16, 1951, an area of dead fishes was observed associated with discolored sea water in the vicinity of Whitewater Bay, which is located on the southwest coast of the Florida peninsula. A sample of this water taken on May 18, 1951, collected from North River on the northeast side of Whitewater Bay, was sent to the Marine Laboratory.

[1]Contribution No. 121 from the Marine Laboratory, University of Miami.

It had a yellowish cast and was said to be of less chromatic intensity than that of the water on May 16. Reuben Lasker[2] isolated a chromogenic bacterium from this water, suggesting to the author that a bacterium might be responsible in some cases for the death of fishes and the characteristic coloration of waters.

An examination of the water by Reuben Lasker revealed the presence of the following genera of dinoflagellates which have been known to cause discolored water: *Prorocentrum, Gonyaulax,* and *Gymnodinium*. Lasker submitted the following report to F. G. Walton Smith, Director of the Marine Laboratory:

> The *Gymnodinium* was not *G. brevis*. The organisms seen were greatly below bloom proportions. Since this sample was taken after the actual mortality occurred, with a heavy rain in between, a bloom may have been present [previously]. Quantitative counts will be made after a two week settling period. Nutrient agar plates were streaked from sea water (a) after dilution, and (b) straight from the sample. The latter showed a distinct coloration similar to that caused by members of the genus *Flavobacterium*. The pigment is being analyzed and subcultures of the bacterium are growing. Further study is required for favorable conclusions.

Shortly after this report was submitted, the culture of this organism was given to the author by Lasker with the aforementioned data.

Dr. Joseph Moore of the Everglades National Park Service supplied the following information gleaned from various observers on the scene:

> Fish mortality and discolored water were observed from May 15 to May 18, 1951. No periodic outbreaks of "red water" in the rivers or large bodies of waters comprising the Whitewater Bay area had been observed prior to this date, although fish kills occur nearly every year. The water obtained in the pooled sample delivered to the Marine Laboratory was collected at Longitudes 80° 54′ 17″ and 80° 54′ 24″; Latitude 80° 54′ 17″. The nearest weather observation station to the collection sites is the Coot Bay Ranger Station, which is located at Longitude 80° 55″ and Latitude 25° 11′. A total of 0.58 inches of rain was measured at this station from May 13 to May 18, 1951. The fish which were found succumbing to the "Red Tide" were as follows: perch [*Gerres*], snapper [*Lutjanus*], snook [*Centropomus*], red fish [*Sciaenops*], needlefish [*Strongylura*], catfish [*Felichthys*], and mullet [*Mugil*]. Other fishes were observed but not identified. No quantitative estimate of the numbers of fishes found dead was given but most observers stated that "there were thousands."

On August 24, 1951, an area of fish mortality was reported in the Indian River at Melbourne, Florida. The author had the opportunity to observe this occurrence of "Red Tide." At the south end of Mullet Creek, Indian River, the water was a deep coffee-color for several miles. The most remarkable feature observed was that no fishes were seen either dead or alive at this time. Captain John Smith of Mel-

[2]Present address: Stanford University, Palo Alto, California.

bourne, a commercial fisherman, stated that this area usually abounded in mullet, which are easily observed when present. He further noted that the discoloration had been evident for two or three weeks. A microscopic examination of discolored water from each observed area was made and revealed the presence of a thecate Peridinium-type dinoflagellate in large numbers. Each contained a large yellow-brown chromatophore, so it is probable that this organism was the cause of discolored water in this area.

The weather report from the Melbourne area for the period from August 1 to August 24, 1951, shows a total precipitation of 1.71 inches. For August, this is a low rainfall. A bacterium containing a red pigment was also isolated from this water. This bacterium developed a red-brown pigment after a period of seventy-two hours of incubation.

Because of the quality of their respective pigments the bacteria isolated from the water at Whitewater Bay will be referred to from this point on as RTY, and the organism from Melbourne as RTR.

The work reported was undertaken with the following objectives in mind: the determination of the physiological and morphological characteristics of RTY and RTR in order to identify them; to ascertain whether RTY and RTR are capable of maintaining themselves on substrates of proteins derived from organisms found in their natural habitats; and to determine whether RTY or RTR were capable of causing fish mortality under controlled conditions.

Materials and Methods

The bacterial specimens were isolated by standard plating methods from pooled samples obtained at the points of fish mortality. Cultures were maintained by weekly subcultures of the organisms on a medium modified by the author from Zobell's 2206 Agar Medium. This medium consisted of the following:

Aged Sea Water	1000 ml.
Agar-agar	15 grams
Bacto-peptone	10 grams

This medium was poured into test tubes, plugged with cotton and autoclaved at 15 pounds of pressure for fifteen minutes and cooled in a slanted position. The tubes were stored at five degrees centigrade until used. All transfers were made from actively growing cultures using sterile techniques. The cultures were plated periodically to assure the absence of contaminants. When a liquid medium was found

necessary the bacteria were grown in a sterile solution of aged sea water with from 0.1% to 1.0% peptone added. This medium was autoclaved at 15 pounds pressure for 15 minutes and then cooled below 40 degrees centigrade before inoculation.

Experimental Procedures and Results

The first objective was to identify RTY and RTR. Ten cultures of each type of determinative medium were used to preclude error in readings. All media were prepared with aged sea water except where otherwise designated. The findings in ten aliquots of each medium are given in Table 1 for RTY and Table 2 for RTR. The morphology and summary of physiological characteristics of RTY and RTR are given below.

TABLE 1
Reaction of RTY to Aliquots of Differential Media

Medium	Aliquots									
Lactose	ag,np	ag,np	ng	ag,np	ag,np	ag,np	ng	ag,np	ag,np	ag,np
Sucrose	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np
Dextrose	ag,np	ng	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np
Levulose	ag,np	ag,np	ng	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np
Maltose	ng	ag,np	ng	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np
Mannitol	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ng	ng	ag,np	ag,np
Salicin	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ng	ng	ag,np	ag,np
Starch	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng
Peptone Broth (1%)	a,np	a,np	a,np	a,np	a,np	a,np	a,np	a,np	a,np	a,np
Peptone Iron Agar	hs,np	hs,np	hs,np	hs,np	hs,np	hs,np	hs,np	hs,np	hs,np	hs,np
Tryptophane	i,np	i,np	i,np	i,np	i,np	i,np	i,np	i,np	i,np	i,np
Gelatin Stab	cl	cl	cl	cl	cl	cl	cl	cl	cl	cl
Nitrate Agar	nr	nr	nr	nr	nr	nr	nr	nr	nr	ng
Nutrient Broth (fw)	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng
Litmus Milk (fw)	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng

a = ammonia
fw = fresh water
ng = no growth
cl = crateriform liquifaction
i = indole
np = not produced
ag = acid and gas
nr = not reduced
hs = hydrogen sulfide

TABLE 2
REACTION OF RTR TO ALIQUOTS OF DIFFERENTIAL MEDIA

Medium	Aliquots										
Lactose	ag,np	ag,np	ag,np	ng	ng	ng	ag,np	ag,np	ag,np	ag,np	ag,np
Sucrose	ag,np	ng	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ng	ng	ag,np
Dextrose	ag,np	ag,np	ag,np	ag,np	ag,np	ng	ag,np	ag,np	ag,np	ng	ng,np
Levulose	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ng	ag,np	ag,np	ag,np	ng
Maltose	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ng	ag,np	ag,np	ag,np
Mannitol	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ng	ag,np	ag,np	ng	ag,np
Salicin	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ag,np	ng	ng	ng	ag,np
Starch	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng
Peptone Broth (1%)	a,np	a,np	a,np	a,np	a,np	a,np	a,np	a,np	a,np	a,np	a,np
Peptone Iron Agar	hs,np	hs,np	ng	hs,np	hs,np	hs,np	hs,np	hs,np	hs,np	ng	hs,np
Tryptophane	i,np	i,np	i,np	i,np	i,np	i,np	i,np	i,np	i,np	i,np	i,np
Gelatin Stab	cl	cl	cl	cl	cl	cl	cl	cl	cl	cl	cl
Nitrate Agar	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr
Nutrient Broth (fw)	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng
Litmus Milk (fw)	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng

a = ammonia
fw = fresh water
ng = no growth
cl = crateriform liquifaction
np = not produced
i = indole
ag = acid and gas
nr = not reduced
hs = hydrogen sulfide

RTY is a non-spore forming, gram negative, straight rod, occurring singly and in chains. It is motile by means of peritrichous flagella.

RTR is a non-spore forming, gram negative, straight or slightly curved rod, motile, but position of flagella unknown.

Because RTY and RTR exhibit identical physiological activities in the presence of the media used a summary of their physiological reactions will be given together. The summary of their physiological activities is given in Table 3.

From these determinations it was impossible to identify completely either of the organisms using the keys available. Bergey's *Manual of Determinative Bacteriology* (Breed and others, 1948) was the author-

TABLE 3

Media	*Summary of Results*
Lactose	no acid or gas
Dextrose	no acid or gas
Sucrose	no acid or gas
Levulose	no acid or gas
Maltose	no acid or gas
Mannitol	no acid or gas
Salicin	no acid or gas
Starch	no growth
Peptone Broth (1%)	ammonia not produced
Peptone Iron Agar	H_2S not produced
Tryptophane	no indole produced
Gelatin Stab	crateriform liquification
Nitrate Agar	nitrates not reduced
Nutrient Broth (F.W.)	no growth
Litmus Milk (F.W.)	no growth

itative source used. The following was obtained from this source for the identification of RTY:

CLASS SCHIZOMYCETES
ORDER EUBACTERIALES
SUB-ORDER EUBACTERIINEAE
FAMILY ACHROMOBATERIACEAE
Genus *Flavobacterium*

The genus *Flavobacterium* is described in Bergey's *Manual of Determinative Bacteriology* (Breed and others, 1948), as follows:

> Rods of medium size forming a yellow to orange pigment on culture media. Motile with peritrichous flagella or non-motile. Generally gram-negative. Characterized by feeble powers of attacking carbohydrates, occasionally forming acid from hexoses but no gas. Occur in water and soil.

Since RTY may not be assigned to any of the described species of this genus the author submits the following species designation for RTY: genus *Flavobacterium* (Bergey, *et al.*); species *piscicida* (sp. nov.) derived from the Latin, meaning "killer of fish." Because RTY is being introduced into the liturature as a new species the author feels it is necessary to give a more detailed description of its characters.

Flavobacterium piscicida n. sp. From Latin, "killer of fish."
Rods: 0.6 to 0.8 by 1.2 to 1.8 microns, straight, occurring

singly and in chains. Motile by means of peritrichous flagella.
Gelatin Stab: Rapid crateriform liquifaction.
Agar Colonies: Spreading, irregular, glistening, undulate to lobate edges.
Agar Slant: Glistening with yellow-orange pigment.
Sea Water Broth: Heavy turbidity, pellicle on top.
Urea: Ammonia not produced.

Further study of RTR is required since this organism cannot be assigned to a genus in Bergey's *Manual* because of the character of it's pigment and pathogenicity. No attempt to classify this organism beyond sub-order Eubacteriineae is made at this time.

The second objective was to obtain additional information on the protein metabolism of each of these organisms. It was found that both of these bacteria required at least 0.1% peptone in the substrate. An attempt was made to grow these organisms on a medium containing only autoclaved sea water. No growth resulted from this attempt. When flasks containing from 0.1% to 1.0% peptone were inoculated with RTY or RTR it was found that the color intensity was more pronounced in the flasks which had the higher percentage of protein.

It was thought desirable to determine whether RTY and RTR were capable of maintaining an active growth on media other than commercial peptone or protein preparations. The following materials were sterilized in flasks containing enough aged sea water to cover the solids: marine snails, fish flesh, beef extract, and concentrated mixed plankton. In all cases RTY and RTR showed a flourishing growth within a period of twenty-four to seventy-two hours.

From the foregoing it can be concluded that RTY and RTR are heterotrophic organisms with a pronounced protein requirement. The source of protein seems to be non-specific.

In order to ascertain the effect of RTY as the causative agent of fish mortality the following experiments were performed.

Three tanks, each containing four gallons of continuously aerated sea water, were used in these experiments. Into each of these tanks the following fishes were introduced: two *Lutjanus apodus*, schoolmaster; two *Eucinostomus pseudogula*, sand perch; four *Fundulus similis*, killifish; twelve *Mollienesia latipinna*, mollie.

These fishes were allowed to remain in the tanks for 48 hours to become acclimated. During this period none of the fishes died or

showed any sign of difficulty. At the end of this forty-eight hour period the tanks were changed as follows:

Tank 1

500 cc of a twenty-four hour culture of RTY in 0.1% peptone solution in aged sea water.

Tank 2

500 cc of an autoclaved twenty-four hour culture of RTY in 0.1% peptone solution in aged sea water. This tank constituted a control for Tank 1.

Tank 3

500 cc of 0.1% sterile peptone solution in aged sea water as an experimental control.

In Tank 1, the two *L. apodus* died within five minutes after the introduction of the inoculum. Before dying, these fishes rose to the surface and displayed gasping actions. After several minutes of this activity they sank to the bottom of the tank and died in a short time. The other fishes in Tank 1 showed no immediate visible effect from the inoculum. In Tanks 2 and 3 the fish appeared indifferent to the inoculum. In Tank 1 all the fishes were dead within twenty-four hours and a heavy bacterial scum was noted on the sides, top and bottom of the tank. A bright orange-yellow pigment was noted in the water at this time. At the end of twenty-four hours all the fishes in Tanks 2 and 3 were alive with the exception of the two *E. pseudogula*. It was reported to the author that the air pressure had been reduced during the night to a point where the fishes might not have been receiving adequate oxygen.

The experiment was then repeated twice using the same materials and methods except that in these experiments the following fishes were used in each tank: one *L. apodus;* two *E. pseudogula;* two *F. similis;* and fifteen *M. latipinna.*

The results of the second and third experiments showed that all the fishes in Tank 1 (live bacterial inoculum) died within twenty-four hours with the *L. apodus* expiring within five minutes. The fishes in Tanks 2 and 3 showed no effect from their inoculum.

The above experiments were repeated three times using RTR instead of RTY. The same procedure was followed and the following fishes were used in each tank for this experiment: one *L. apodus;* two *E. pseudogula;* two *F. similis;* and fifteen *M. latipinna.* In all experiments using RTR no fish mortality was noted.

DISCUSSION

Appraisal of Tables 1 and 2 shows that both RTY and RTR are relatively inactive on carbohydrate media. The physiological characteristics are such that they readily utilize protein as a source of nourishment. When RTY was originally isolated it was found to grow readily on protein and even carbohydrate media suspended in fresh water. This characteristic of the organism quickly diminished until it would no longer grow on any type of fresh water media after the third subculture. RTR has never demonstrated growth on a fresh water substrate. From its colony characteristics it was noted that RTR is capable of rather dramatic dissociations especially in the presence of nitrates.

The rapidity with which RTY causes the mortality of the tested species of fishes leaves little doubt as to its lethal action on those fish. The fact that only the living bacteria appear capable of causing mortality, while autoclaved organisms apparently have no effect on the fish, points to the conclusion that the organism produces a powerful exotoxin which is thermolabile. Burrows (1949) states that exotoxins are apparently protein in nature, large molecules which are synthesized by the organisms capable of forming them, and they have many properties in common with enzymes. Frobisher (1949) states that exotoxins are poisonous waste products excreted by the bacteria into their environment. The statements of both of these men suggest a cause of mortality. It must be stated, however, that further investigation is needed to establish fully the properties of this toxin. The use of cell free filtrates, minimal heat application, and determination of the amount of inoculum necessary to cause death of the fishes is suggested in further studies.

The experiments performed during this investigation bear out the contention that RTY is a possible cause of fish mortality and therefore it is logical to suggest that the presence of this organism in large quantities could cause fish mortality under natural conditions. Laboratory experiments using *Flavobacterium piscicida* (sp. nov.) were carried out with pure cultures. *Gymnodinium brevis* has not as yet been grown in pure culture which makes complete evaluation of the present results difficult.

In the outbreak of "Red Tide" occurring in the Gulf of Mexico off the western coast of Florida in October and November of 1952, *G. brevis* was detected in great numbers. It has been assumed that it is

this organism which kills fish. Bacterial smears made of *Gymnodinium* cultures taken from this water were made by the author. An extremely large bacterial flora was noted and a chromogenic bacterium was isolated by plate method. This organism is now in pure culture at the Marine Laboratory and the Botany department of the University of Miami.

CONCLUSIONS

It has been shown that a bacterium isolated from "Red Tide" water is capable of killing certain fishes under laboratory conditions. It seems plausible to assume therefore that the bacterium possibly had a role in bringing about the mortality associated with "Red Tide" outbreaks. The relative importance of dinoflagellates and bacteria in causing mortality is not known and should be investigated.

It seems desirable to investigate for the presence of chromogenic bacteria during outbreaks of Red Tide to determine if such bacteria are always present during blooms of *Gymnodinium brevis*. Quantitative studies should also be made.

The bacterium designated as *Flavobacterium piscicida* (sp. nov.) has been identified by its physiological activity and its morphology. The bacterium here known as RTR has been assigned to the suborder Eubacteriineae.

It has been found that RTR and *Flavobacterium piscicida* (sp. nov.) are capable of maintaining growth on a substrate of protein from animals found in their natural habitats and that a minimal concentration of 0.1% peptone is necessary for growth.

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THE POSTLARVAL DEVELOPMENT OF THE FISHES OF THE FAMILY GEMPYLIDAE FROM THE FLORIDA CURRENT. I. *NESIARCHUS* JOHNSON AND *GEMPYLUS* CUV. AND VAL.[1]

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ABSTRACT

Sixty-two specimens of postlarval and juvenile gempylids, ranging in size from 3.5 to 254 mm standard length, mostly from the Florida Current, are described and fifteen are illustrated. The postlarval development of *Nesiarchus nasutus* Johnson and two morphologically distinct forms belonging to the genus *Gempylus* Cuv. and Val. are described. Food and vertical distribution of the larvae and spawning of these fishes in the areas of the Caribbean and the Florida Current are discussed.

In view of the fact that so little is known about the development and life histories of marine fishes, the Marine Laboratory, University of Miami, began, in February, 1952, a study of the larval fish from the Florida Current. The present paper is the first of a series to come out of this work.

The program has been supported by the National Geographic Society since February, 1953, and, to it, the author wishes to express her deepest gratitude. Since the majority of the plankton hauls which yielded the material for this study were made by the Marine Laboratory vessels *T-19* and *Physalia,* the author is indebted to their captains and crews, in particular to David L. O'Berry. She wishes to thank Dr. Leonard P. Schultz of the United States National Museum for the opportunity of working in his department in the summer of 1953, for the loan of specimens and for his valuable criticism of this paper. The author is grateful to Mr. William W. Anderson, U. S. Fish and Wildlife Service, for the loan of specimens from the larval fish collections of the South Atlantic Fishery Investigation. She is also grateful to Mrs. Joan F. Clancey who assisted in the general plankton sorting and to Mr. Gilbert L. Voss for his suggestions and advice in the preparation of this paper.

INTRODUCTION

The fishes of the family Gempylidae, commonly called escolars and snake mackerel, are mainly inhabitants of the open ocean, widely dis-

[1]Contribution No. 126 from The Marine Laboratory, University of Miami.

tributed, with most of the species being found in both the Atlantic and Pacific Oceans. The family consists of about 12 genera and 13 species and, as a whole, is considered to be a very predacious group and an inhabitant of the deep waters, usually between 180 and 1000 meters. The young stages, however, have been taken mostly from the surface waters from about 0 to 275 meters.

Many of the gempylids are valued as food in different parts of the world. *Promethichthys prometheus* (Cuvier and Valenciennes) is reportedly one of the commonest and cheapest fishes in the Madeira markets during the summer months, where it is sold in bundles chiefly to the Portuguese (Lowe, 1843). This same species is also used as food in Japan (*Albatross I* secured three adults from the Tokyo Market, now deposited in the USNM). Also see Kamohara (1938). *Ruvettus pretiosus* Cocco, commonly called "the Escolar" and "Oilfish" is commercially sought after for its excellent flesh and for the medicinal (purgative) value of its oil in Cuba, the Canaries and parts of the South Pacific (Goode and Bean, 1895; Gudger, 1925, 1927, 1928; and Nordhoff, 1928).

According to Grey (1953), the family Gempylidae is represented in the western North Atlantic (from the north coast of South America northward) by eight species:

?Lepidocybium flavobrunneum (Smith)[2]
Ruvettus pretiosus Cocco
Epinnula magistralis Poey
Epinnula orientalis Gilchrist and von Bonde
Promethichthys prometheus (Cuvier and Valenciennes)
Neolotus tripes Johnson
Nesiarchus nasutus Johnson
Gempylus serpens Cuvier and Valenciennes

These fishes have been rarely caught and are very little known from off the south Atlantic coast of the United States.

Records of postlarval and juvenile stages of gempylids are scattered through the literature (Lowe, 1843; Günther, 1860, 1887, 1889; Johnson, 1865; Lütken, 1880; Goode and Bean, 1895; Regan, 1916; Breder, 1927; Roule and Angel, 1930; Norman, 1930; and Longley and Hildebrand, 1941) with many of the identifications uncertain, usually being based on only one or two specimens. Since no sizeable series and little data have been available up to this time, nothing has

[2] *Thyrsites niger* Poey described from a fragment is possibly synonymous with *Lepidocybium flavobrunneum* (Smith), (Munro, 1949).

been done on the biology and development of these fishes with the exception of Lütken's accounts of two small series of young gempylids which he referred to *Neolotus tripes* and *Gempylus serpens*.

Material and Methods

Collection of Material. The greater amount of the material was obtained from two routine stations in the Florida Current off Miami occupied by the Marine Laboratory vessels in the course of the general larval fish program supported by the National Geographic Society and in conjunction with earlier and concurrent plankton work at the laboratory. This material was chiefly augmented by specimens collected by the U. S. Fish and Wildlife vessels *M/V Theodore N. Gill, Albatross I, Albatross III,* the U. S. Hydrographic vessel *USS San Pablo,* the Cuban Hydrographic vessel *Yara,* and the *Carnegie* Plankton Expedition.

The first routine Marine Laboratory station, designated as NG, was located on the west side of the Florida Current (25° 43′ to 26° 08′ N., 79° 23′ to 79° 56′ W.), about ten miles east of the Miami sea buoy, where the depth ranges between about 150-350 meters. The second routine Marine Laboratory station, designated as SL, was located on the east side of the Florida Current (except for SL 8 through 11, which were at the NG station location), about five miles west of Cat Cay, Bahamas (25° 35′ N., 79° 25′ W.), where the depth averages about 740 meters.

The plankton from these two stations was collected with 70 cm diameter closing nets of the Discovery type, the leading third of the nets consisting of ¼ inch side mesh, the central third of stramin, and the trailing third of No. 10 silk bolting cloth with a wide mouth quart jar screwed into a secured ring at the end.

These stations were occupied at least once a month, weather permitting, and worked over a 24-hour period. At the SL station, nine nets were used in each flight, sampling the waters from the surface to the bottom. The nets were approximately 100 meters apart and run in series of four hauls. Over a 24-hour period, eight complete flights were usually made.

A depth-distance recorder (described in Miller *et al* 1953) was attached to the cable near the nets on each haul. Bathythermographs and reversing thermometers recorded temperatures and Secchi disc and photocells were used to determine water transparency.

Data, as accurate as possible, were thus available on location, depth,

temperature and time when each haul was made. The general hydrographic data from the NG station was reported on by Miller *et al* (1953).

All fish and eggs were sorted from the general plankton. The larval fish were then sorted to family when possible, and, as sufficient series developed in the gempylids, they were identified to species.

The terminology of early fish stages herein employed follows that given by Hubbs (1943). LARVA (or larval) refers to the developmental stages from the time of hatching to that of transformation into the juvenile. These stages are divisible into prolarva and postlarva. PROLARVA refers to larva still bearing yolk. POSTLARVA refers to larva after the time of yolk absorption, up to the time of transformation into the juvenile. JUVENILE is understood as the young essentially similar to the adult.

Identified postlarval series of each of the fishes reported on in this paper will be deposited in the United States National Museum as well as in the larval fish collections of the Marine Laboratory. USNM numbers refer to United States National Museum catalogue numbers.

Measurements, Proportions and Counts. All measurements were made with a micrometer eyepiece on the smaller specimens and with calipers on the larger specimens. All counts and lateral measurements were made on the left side unless that side was damaged. Total length was not considered valuable in this study, and, therefore, was not taken.

Definitions of the measurements used are as follows: STANDARD LENGTH, in the smaller specimens before the appearance of the urostyle, is measured from the tip of the snout to the tip of the vertebral column. In those specimens in which the urostyle is formed, the measurement is to the middle of the caudal base. The DEPTH is measured at the origin of the pelvic spines. The HEAD is measured from the tip of the snout to the posterior edge of the gill opercle exclusive of projecting spines. The SNOUT is measured from the tip of the upper jaw to the anterior edge of the eye orbit. The EYE refers to the greatest horizontal diameter of the bony orbit, inside measurement. The PELVIC SPINE and FIRST DORSAL SPINE refer to the lengths of these respective parts. Only completely formed spines and soft rays are included in the counts. All measurements are given in millimeters. Proportions, or indices, are expressed as a percentage of the standard length.

Systematic Value of Larval Characters

There are various larval features that serve to distinguish the very young stages of one family of fishes from another. This, however, does not hold true for all families nor even for all orders. After a close study of a sufficiently large series within a family, it is often possible to separate out independent smaller series by a further refinement of the general family larval characters, in addition to more specific characters. In all cases, of course, the myotome and ray counts are of great help in identifying the later postlarval stages; but, in the very early stages, they are of little value; the myotomes are indistinct and the complete set of rays are unformed. The one most necessary requirement for specific identification in larval fishes is a large size-series.

In the family Gempylidae, the height of the spinous dorsal, the length of the pelvic spines, and the spinous structure of the preopercular margin prove to be the most taxonomically important larval characters. Of these, the latter has been the most valuable in distinguishing species. The outer margin of the preopercle has a basic 4-spined pattern with a supplementary spine originating just above the third spine.

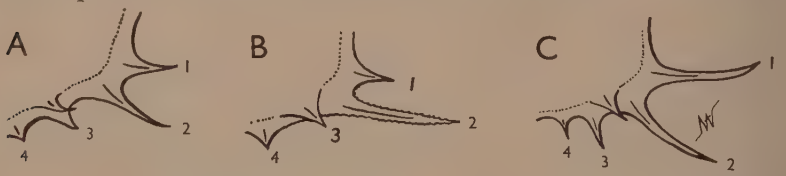

Figure 1. Preopercular spine outlines in 6.9 mm standard length specimens. A. *Nesiarchus nasutus* Johnson; B. *Gempylus* A; C. *Gempylus* B.

The specific modifications of the basic pattern are shown in Figure 1. Because of the importance of preopercular spination in this group, the author has adopted the use of a formula to give the number of spines and their comparative lengths in the different species.

Systematics

Nesiarchus nasutus Johnson

Figures 1A; 3; 4; 5.

Nesiarchus nasutus Johnson, 1862. Proc. Zool. Soc. London: 173-175, pl. 22.

SPECIMENS STUDIED.

Fourteen specimens (5.2-17.5 mm standard length), from 5 regular NG stations (complete data given in Table 1).

Seven specimens (5.6-16.7 mm standard length), from 5 regular SL stations (complete data given in Table 1).

One specimen (5.1 mm standard length), supplementary SL station, May 5, 1952, 0750 hours, surface, 25° 14′ N., 79° 12′ W.

Three specimens (7.2-8.7 mm standard length), M/V *Theodore N. Gill,* cruise No. 3, station No. 31, July 29, 1953, 2257-2319 hours, 0-25 meters, 31° 01.5′ N., 80° 07.5′ W.

One specimen (188 mm standard length), *Yara,* station No. 39, December 9, 1950, 24° 03.5′ N., 82° 04′ W.

Two specimens USNM No. 151899 (225 and 254 mm standard length), *Albatross III,* station No. 22, tow No. 2, May 28, 1949, 376-394 meters, 33° 00.5′ N., 77° 07.5′ W. to 33° 03′ N., 77° 05′ W.

Two specimens, USNM No. 153677 (7.2-and 23.5 mm standard length), *Albatross I,* station No. 20020, November 16, 1919, 0-200 meters, 23° 58′ N., 81° 59′ W.

Spawning. With so few records of adult *Nesiarchus nasutus,* it is little wonder that nothing is known of its spawning. There are no records of the larval stages of this species having been taken. In a review of the young gempylids described and referred by past authors to various other species, none appear to be *N. nasutus.*

This paper contains the study of 26 postlarval specimens of this fish, ranging in size from 5.1 to 23.5 mm standard length, from the Florida Straits, the waters between Miami and Cat Cay, Bahamas and off Brunswick, Georgia (Figure 2). This distribution follows the course of the Florida Current, with the larvae occurring on the east and west sides as well as the middle of the Current off Miami. These facts reveal the Caribbean area and that of the Florida Current to be a spawning area for this fish. Since the size ranges of the specimens from the three localities are relatively uniform (Florida Straits, 7.2-23.9 mm; between Miami and the Bahamas, 5.1-17.5 mm; off Brunswick, 7.2-8.7 mm in length), it appears that spawning takes place over a sizeable area.

No prolarvae were taken; the smallest postlarva was 5.1 mm standard length. This specimen was probably not more than a week old. Specimens were taken every month between Miami and the Bahamas except in April, June, July, September and December. In the Florida Straits, they were taken in November and, off Brunswick, in July. Since the months in which they were not taken appear to be sporadically scattered throughout the year, their absence is probably due to poor sampling, Larvae of 5.0-7.0 mm length occurred every month that the species was taken in the plankton. It can, therefore, be concluded that *N. nasutus* spawns in the Caribbean and Florida Current

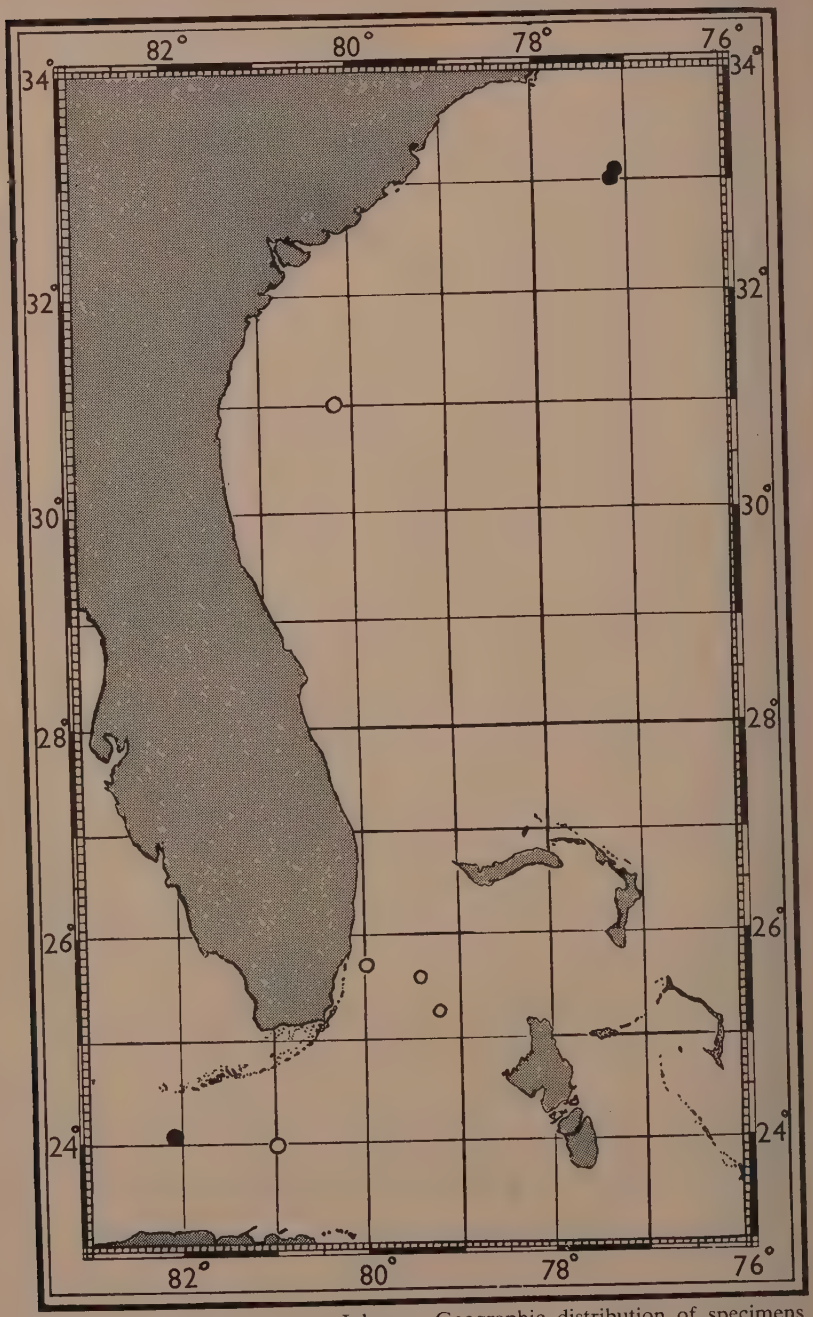

FIGURE 2. *Nesiarchus nasutus* Johnson. Geographic distribution of specimens included in this study. Open symbol, postlarval specimens; closed symbol, juvenile specimens.

areas through the twelve months of the year. From the material available, it is impossible to determine anything on the growth rate of this fish.

Development of the Young. The postlarvae of *Nesiarchus nasutus* are distinguished from those of other gempylids chiefly by their low spinous dorsal, short pelvic spines accompanied by rays, and a preopercular spine pattern (Figure 1A) of the length order of 2-1-3-4, with the first, second and third spines usually upturned.

All proportions and fin counts of the specimens described below are given in Tables 2 and 3.

The smallest specimens, 5.1-5.6 mm, are more elongate and slender than the slightly larger specimens. In the 5.1 mm larva (Figure 3A), the snout is short, 11.8 percent of the standard length. Six dorsal spines are completely formed with indications of several more. No fin rays are in evidence, except for one indistinct one following the short pelvic spine. The vertebral column is still straight, but the beginnings of the caudal base are evident. There are scattered large chromatophores on the head and on the abdominal wall. A few more are located posterior to the anus on the ventral surface, with an additional few along the middle of the sides. A few large spots are on the spinous dorsal. In three specimens from 5.1 to 5.6 mm and one 6.0 mm, there are several teeth projecting outward from the anterior edge of the lower jaw.

The 6.0 mm specimen, illustrated in Figure 3B is typical of the three of that size which were studied. Over the short size interval of 0.9 mm, the fish becomes much more adultlike. The body deepens and the snout and head lengthen, giving the fish a more compact appearance. The pelvic and dorsal spines are proportionately longer. The dorsal spines number 12 and there are indications of dorsal and pelvic soft rays. The urostyle makes its first appearance and there are suggestions of caudal rays. The number of chromatophores on the head and the abdominal wall increases. Additional ones appear along the dorsal line and on the spinous dorsal. In this particular specimen the protruding teeth from the lower jaw are no longer evident and the cartilaginous processes of the upper and lower jaw so characteristic of the adult, first appear in a 6.2 mm larva and are well defined in the 7.0 mm specimens.

By the time the larva has grown to 7.5 mm (Figure 3C), many of the adult characters are well defined (e.g., 20 dorsal spines). The

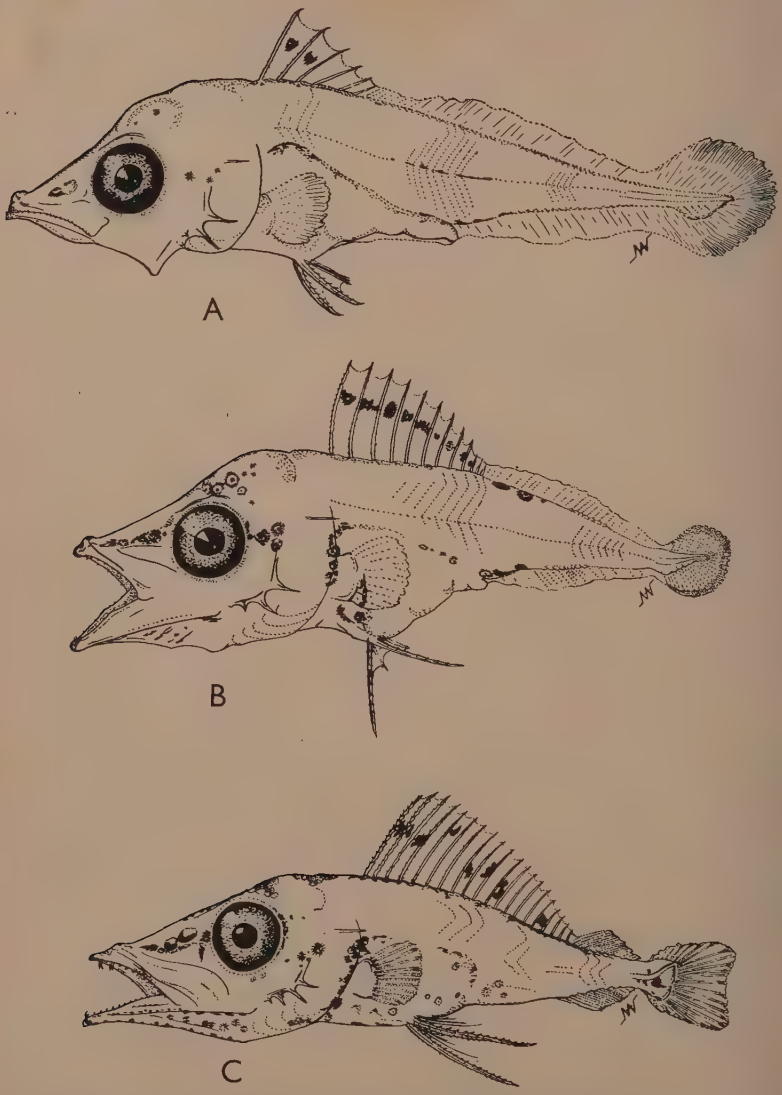

FIGURE 3. *Nesiarchus nasutus* Johnson. Postlarval specimens. A. 5.1 mm standard length; B. 6.0 mm standard length; C. 7.5 mm standard length.

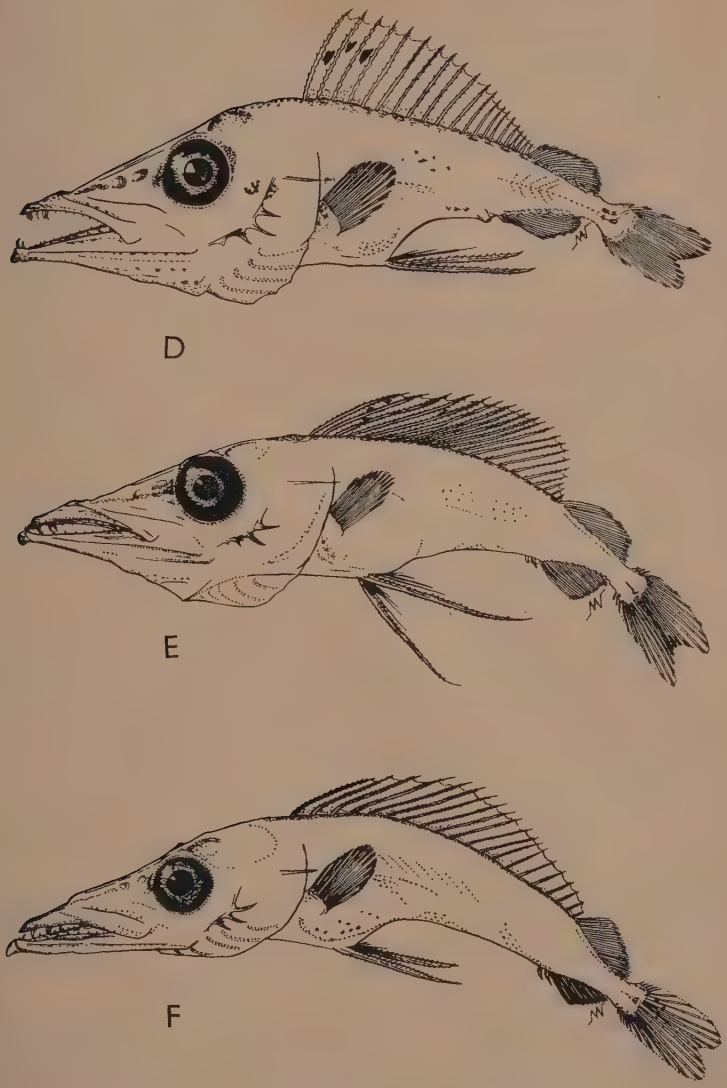

FIGURE 4. *Nesiarchus nasutus* Johnson. Postlarval specimens. D. 9.3 mm standard length; E. 11.3 mm standard length; F. 17.5 mm standard length.

snout is noticeably longer, 21.4 per cent, and the head lengthens to 49.4 per cent, both of the standard length. Fifteen dorsal and 16 anal soft rays are fully developed, but no anal spines are formed. The pelvic spines proportionately lengthen and are followed by 4 soft rays. The caudal fin is well defined and shows a tendency to fork. The number of chromatophores increase on the head and the abdominal walls and increased pigmentation along the base of the spinous dorsal is evident. Large pigment spots appear on the caudal base. The broad groove between the eyes is first evident at about this stage. The curved fangs of the upper and lower jaws are distinguishable as well as the cartilaginous processes of the jaws.

From about the 8.0 mm size on, the depth and eye diameter become relatively less. In the 9.3 mm larva (Figure 4D), the snout is still more elongated with the fangs and cartilaginous processes well developed. The 13 rays of the pectoral fin are now formed. The dorsal and anal fins both contain 17 soft rays. Two sharp dagger-shaped spines are present in front of, and connected to, the anal fin. The second is the larger. The caudal fin is pronouncedly forked at this stage. Adult pigmentation predominates over the large individual chromatophores present in the larvae up to this size.

At about the 11.3 mm size (Figure 4E), the head reaches its greatest relative length of 51.4 per cent of the standard length and the pelvic spines their greatest relative length of 29.2 per cent. There are 21 dorsal and 20 anal soft rays.

After the 11.7 mm size, the snout becomes relatively shorter during growth. In the 17.5 mm specimen (Figure 4F), the spinous dorsal is relatively lower, assuming the long low appearance present in the adult. There are 23 soft rays in the dorsal and 22 in the anal, with no sign, as yet, of the separate finlets. Of the two preanal spines, the second one is the stouter and about one-third longer than the first. The cartilaginous processes of the jaws are well developed. The 23.5 mm specimen was in poor condition and therefore rendered incomplete counts. The relative depth, eye diameter and length of the head, snout, pelvic and dorsal spines continue to decrease. The lateral line can not be discerned in any of the postlarval specimens.

In the 188.0 mm juvenile (Figure 5), the fish appears to be at its slenderest stage, the greatest depth only 8.7 per cent of the standard length. In this specimen, as well as the 225 mm and 254 mm specimens, the first preanal spine is the stouter and larger of the two. Grey (1953) found two preanal spines to persist in the 287 mm and the

295 mm specimens she examined. In her next larger specimen of 388 mm, apparently only the single spine found in the adults remained.

In the three juvenile specimens, 188 mm-254 mm, two dorsal and two anal finlets are present. The finlets are attached by membranes to each other and to the main body of their respective fins. Where the pigment persists, the head and sides of these larger specimens are dark brown and the belly silvery.

Throughout the larval stages and in the juveniles studied, the greatest body depth is at the pelvic base. Grey (1953) found this to be true in her two smallest specimens (287 mm and 295 mm) with a shift backwards to past the middle of the body in her larger specimens (572.5 and 737 mm).

Figure 6 depicts the relationships of the various measurements to standard length of all of the postlarval and juvenile specimens examined by the author, in addition to those reported on by Grey (1953) and the type specimen of Goode and Bean. In order to include the wide length range, it was necessary to use 4 cycle semi-log paper. This gives the various peaks on the graph a much sharper appearance than is actually true.

The exaggerated characters which distinguish the postlarval stage reach their peaks over a range of about seven millimeters, from the 6 mm to the 13 mm size stages. The change over into the juvenile is then a gradual process. Perhaps a peak in juvenile development, similar to that in postlarval development, can be interpreted from the second peak in Figures 6A and 6B occurring at about 300 mm standard length. The relationship of snout to head reveals no postlarval or juvenile peaks but presents a continuous curve over the entire size range.

Food. The stomach contents of all of the larval and juvenile specimens in the possession of the author were analysed. As has been found in most larval fishes, the basic food appears to be copepods. The largest number found in any one larva examined was 13 in a

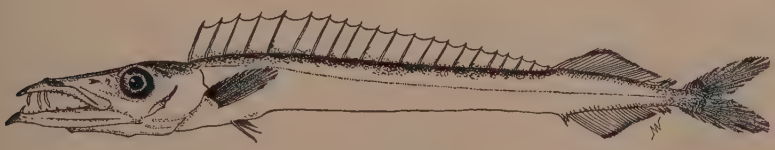

FIGURE 5. *Nesiarchus nasutus* Johnson. Juvenile specimen, 188 mm standard length.

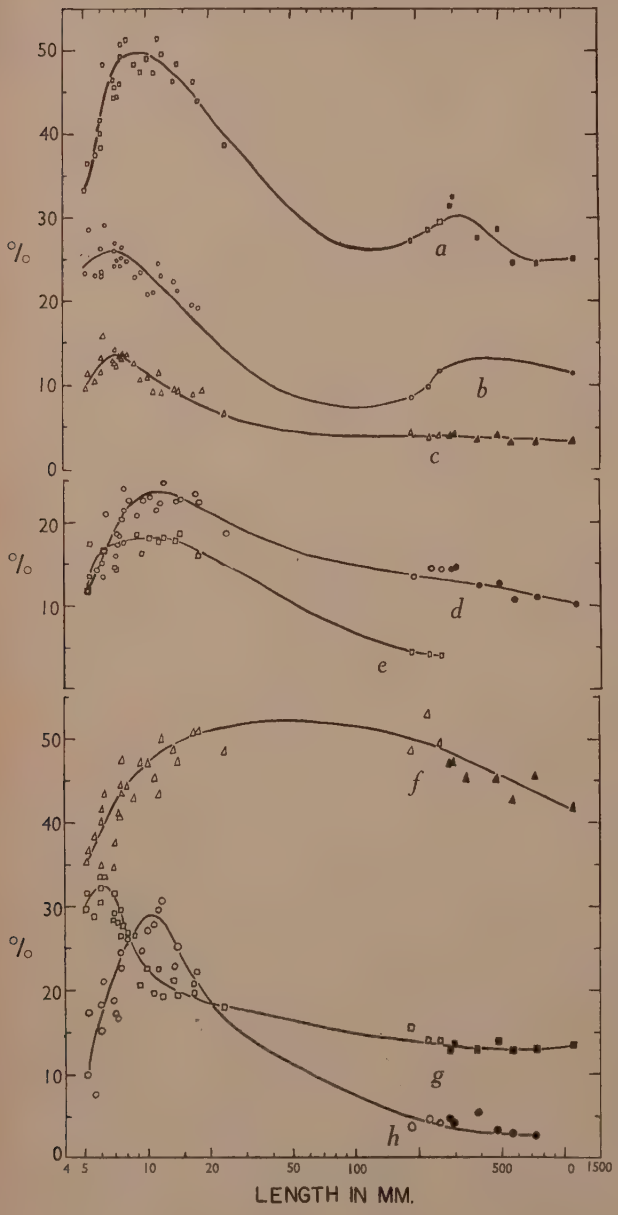

FIGURE 6. *Nesiarchus nasutus* Johnson. Change of bodily proportions during growth. a. Relationship of head length to standard length; b. relationship of depth to standard length; c. relationship of eye diameter to standard length; d. relationship of snout length to standard length; e. relationship of first dorsal spine length to standard length; f. relationship of snout length to head length; g. relationship of eye diameter to head length; h. relationship of pelvic spine length to standard length. Open symbols represent specimens examined by the author; closed symbols represent specimens examined by other authors.

7.5 mm specimen. Only the remains of copepods could be distinguished in the stomach contents of the smaller larvae. Fish first occurred when the remains of two were found in an 11.3 mm young.

All of the identifiable copepods were of the genus *Corycaeus*. This genus, composed mostly of tropical species, is abundant in the plankton off Miami (Wilson, 1932).

The 225 mm juvenile had in its stomach the remains of four viper fishes, *Chauliodus sloanei* Schneider. The heads of these four specimens were intact and had the length measurements of 11.5, 11.0, 9.0 and 7.0 mm. From the measurements given by Ege (1948), 14.5% was assumed to be about average for head length in per cent of standard length for *Ch. sloanei* in the Atlantic. Using this figure, it was calculated that the four specimens of *Ch. sloanei* consumed by the 225 mm juvenile *N. nasutus* were of approximately 79, 76, 62 and 48 mm standard length. All four were in about the same stage of digestion, thereby implying their almost simultaneous capture.

The stomach of the 254 mm juvenile *N. nasutus* contained one squid beak, the remains of one *Chauliodus* sp. and three eels of the family Nemichthyidae (one exceeding 230 mm in length). The Nemichthyids are relatively common deep-water eels in tropical waters. Beebe (1937) and Beebe and Crane (1937) found them to be living between 91 to 1828 meters around Bermuda.

Grey (1953) makes the only other mention of food of *N. nasutus*. In the stomach of a 388 mm specimen from off Bermuda, she reported the remains of a cuttlefish. Since no cuttlefish are found in the Western Atlantic, this was probably the remains of a squid, perhaps *Sepioteuthis sepioidea,* whose general appearance is that of a cuttlefish.

Vertical Distribution of the Young. The 27 postlarval specimens from the Florida Current reported on in this paper were taken from 0 to around 200 meters depth (Figure 7). Ninteen of these were from the upper 50 meters of water, with 6 being taken at the surface. Two specimens were taken at 55 meters depth and the remaining 5 from between 100 and 188 meters. There was neither depth nor time datum on the capture of one specimen. All were taken singly with the exception of four hauls which yielded 8, 3, 2 and 2 specimens respectively.

Twenty-one of the larvae were taken at the two regular Marine Laboratory stations over a three-year period in which about 633 net hauls were made. The occurrence of the larvae of *N. nasutus,* there-

fore, could certainly not be called common, but on the other hand, not rare.

At the NG station, where the depth ranges between 150 and 350 meters, 12 specimens were taken in the upper 55 meters and 2 were taken at 135 meters depth. At the SL station, where the depth averages about 740 meters, 5 specimens were from around 188 meters. Equal sampling was done at all depths from the surface to the bottom.

The larvae were found in waters through a temperature range of 13.0°-28.1°C., and a salinity range of 35.94-36.10‰. They occurred at depths having illumination of the value of 10^{-0} to those having a value of 10^{-6} (illumination values as defined by Moore, 1950). The amount of material and data at hand is inadequate to warrant any speculation as to what physical factor or factors, if any, limit their vertical range. A statistical treatment of the data showed no evidence that the larvae of this fish migrates diurnally.

There appears to be a tendency for the larvae as they grow to seek greater depths (Figure 7), for only those over 6.9 mm in length were taken below 50 meters. Unfortunately, there is no depth datum on the

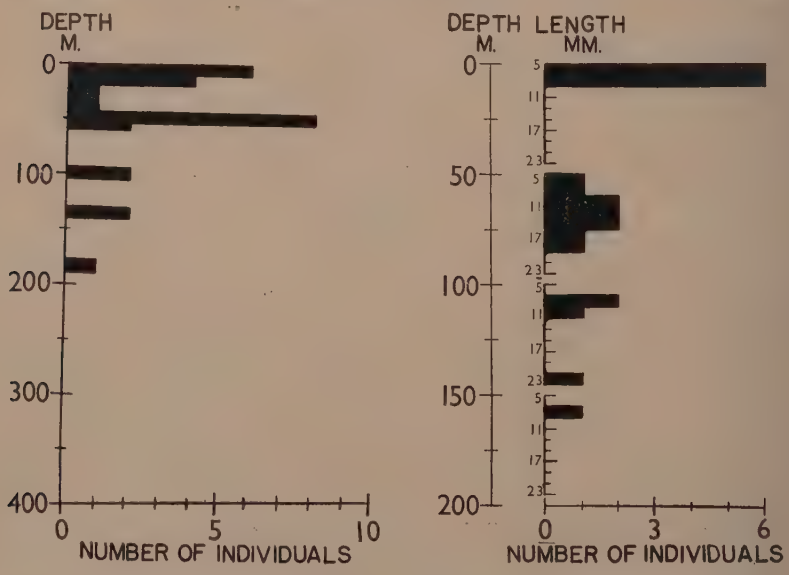

FIGURE 7. *Nesiarchus nasutus* Johnson. Depth distribution of postlarval specimens included in this study.

188 mm juvenile, but the 225 and the 254 mm specimens were from 376 to 394 meters depth. All other records of juveniles and adults from the Western Atlantic were from depths of between 228 and 1500 meters. It is probable that this fish lives most of its adult life in deep water, the larvae, on the other hand, hatch and develop in the upper waters where planktonic food is most plentiful, and then, as they grow, seek the greater depths of their parents.

Genus *GEMPYLUS* Cuvier and Valenciennes

SNAKE MACKEREL

Gempylus Cuvier and Valenciennes, 1831. Hist. Nat. Poiss., 8: 207. (Genotype, *Gempylus serpens* Cuvier and Valenciennes).

LARVAL AND JUVENILE SYNONYMY.

Gempylus serpens Cuvier and Valenciennes. Lütken, 1880: 448 (illustrates and describes development of a small series of *G. serpens*, 9.0-197 mm total length). Breder, 1927: 28 (40 mm specimen from West Indian area tentatively identified). Longley and Hildebrand, 1941: 72 (fragments of young *G. serpens* in wastes of bird rookery near Tortugas, Florida).

This genus is widely distributed in all tropical waters. All described specimens are generally referred to a single species, *Gempylus serpens* Cuvier and Valenciennes. The author has found two distinct larval forms belonging to this genus. Rather than refer any one or both specifically to *G. serpens,* it was thought best to identify them as *Gempylus* A and *Gempylus* B. Specific identification must await a closer study of the adults and enlarged size-series through the juvenile stage.

Young specimens referred to *Gempylus serpens* have been reported by Lütken (1880), Breder (1927), and Longley and Hildebrand (1941). Lütken had a scattered series of specimens ranging in size from a larva of 9.0 mm to adults of 980 mm total length. They were from various localities: the China Sea; the Pacific Ocean off Mexico and Peru; and the Atlantic Ocean along the equator, following the course of the South Equatorial Current and, again along the 20° N. parallel, following the North Equatorial Current. Breder lists a tentatively identified 40 mm standard length specimen from the West Indian area, and Longley and Hildebrand report finding fragments of young *G. serpens* in wastes of a bird rookery near Tortugas, Florida.

Gempylus A

FIGURES 1B; 9; 10.

SPECIMENS STUDIED.

Seven specimens (3.5-6.7 mm standard length), from 5 regular NG stations (complete data given in Table 4).

One specimen (4.2 mm standard length), supplementary NG stations No. 11, haul No. E-2, *Yara,* December 10, 1950, 0650 hours, *ca.* 182 meters, 24° 03.5′ N., 82° 04.1′ W.

Six specimens (3.9-8.0 mm standard length), from 3 regular SL stations (complete data given in Table 4).

Two specimens USNM No. 163349 (6.8 and 14.2 mm standard length), *Carnegie* Plankton Collection Station between station Nos. 1 and 2, sample 8, bottle 1459, May 16, 1928, 37° 45′ N., 53° 26′ W.

One specimen USNM No. 163352 (6.0 mm standard length), *Carnegie* Plankton Collection Station No. 15, sample 101, bottle 4268, August 11, 1928, 38° 39′ N., 48° 48′ W.

Two specimens USNM No. 163353 (4.5 and 6.5 mm standard length), *Carnegie* Plankton Collection Station No. 16, sample 107, bottle 4299, August 13, 1928, 36° 47′ N., 46° 31′ W.

Three specimens USNM No. 113291 (11.7, 14.3 and 21.5 mm standard length), USS *San Pablo,* net No. 1, February 11, 1951, 0-550 meters, 30° 31′ N., 42° 42′ W.

One specimen (82.0 mm standard length), J. K. Howard, from stomach of a dolphin, *Coryphaena hippurus* L., November 15, 1953, off Alligator Key, Florida, (*Gempylus,* but not identified to form).

One specimen (109.0 mm standard length), M/V *Theodore N. Gill,* cruise No. 2, between station No. 80 and special station No. 1, from the stomach of a dolphin, *Coryphaena hippurus* L., May 12, 1953, 1530 hours, 34° 29.5′ N., 74° 38.5′ W., (*Gempylus,* but not identified to form).

Spawning. The author has 22 larval specimens belonging to the genus *Gempylus* and here referred to *Gempylus A,* ranging in size from 3.5 to 21.5 mm standard length. They were taken from the Florida Straits, the waters between Miami and Cat Cay, Bahamas and in the Central Atlantic (Figure 8). Since larvae of 3.5-4.2 mm size range were taken in the Florida Current between the Straits and the Bahamas, it establishes the areas of the Caribbean and Florida Current as spawning regions for this fish. Larvae were taken in December, January, February, May and August. With the size range of the specimens not varying from one month to the next, it may be inferred that continuous spawning occurs during all the months in which they were taken. The amount of material is insufficient to show whether the spawning period is a continuous one over the twelve months or broken into two parts, winter-spring and late summer.

The 5 larvae taken by the *Carnegie* Plankton Expedition and the three taken by the USS *San Pablo* are all from an area 488 x 644 nautical miles. Much of this area lies over the Atlantic Ridge. The larvae from this section ranged in size from 4.5-21.5 mm.

Material and data are insufficient for any determination of growth rates.

Development of the Young. The larvae of *Gempylus* A are the most distinctive of the three forms described in this paper. They are easily recognized by their very high spinous dorsal, long, strongly serrated pelvic spines with no accompanying soft rays, and a preopercular spine pattern of the length order of 2-1-4. The third spine is missing and the second serrated and two or more times as long as the first, depending on the size stage of the larva. Larvae exceeding about 8.0 mm in standard length are further distinguished by the high dorsal spine count approaching that of the adult.

All proportions and fin counts of the specimens described below are given in Tables 5 and 6.

Figure 9A of a 4.0 mm standard length larva, shows the fish in its earliest stage of development. It is quite deep and stubby in appearance. There are 5 dorsal spines, one more than is present in the 3.5 and a 3.9 mm specimen. There is no suggestion of soft rays. The out-

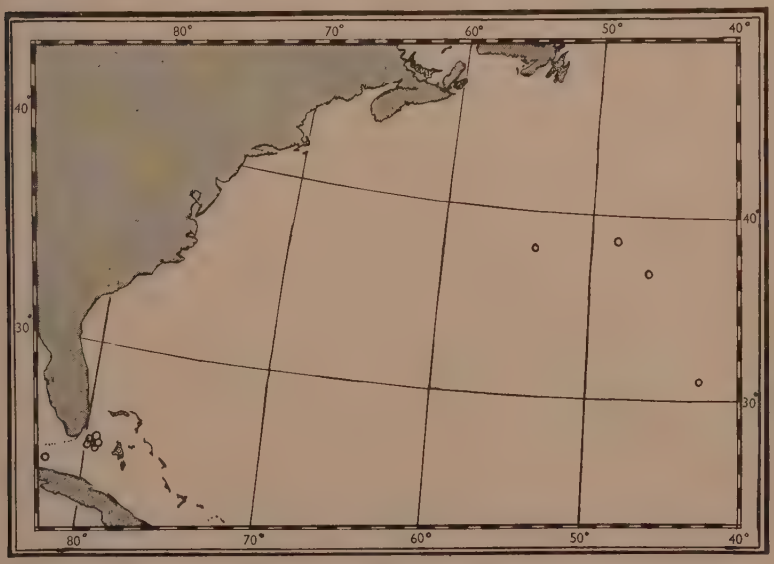

FIGURE 8. *Gempylus* A. Geographic distribution of specimens included in this study.

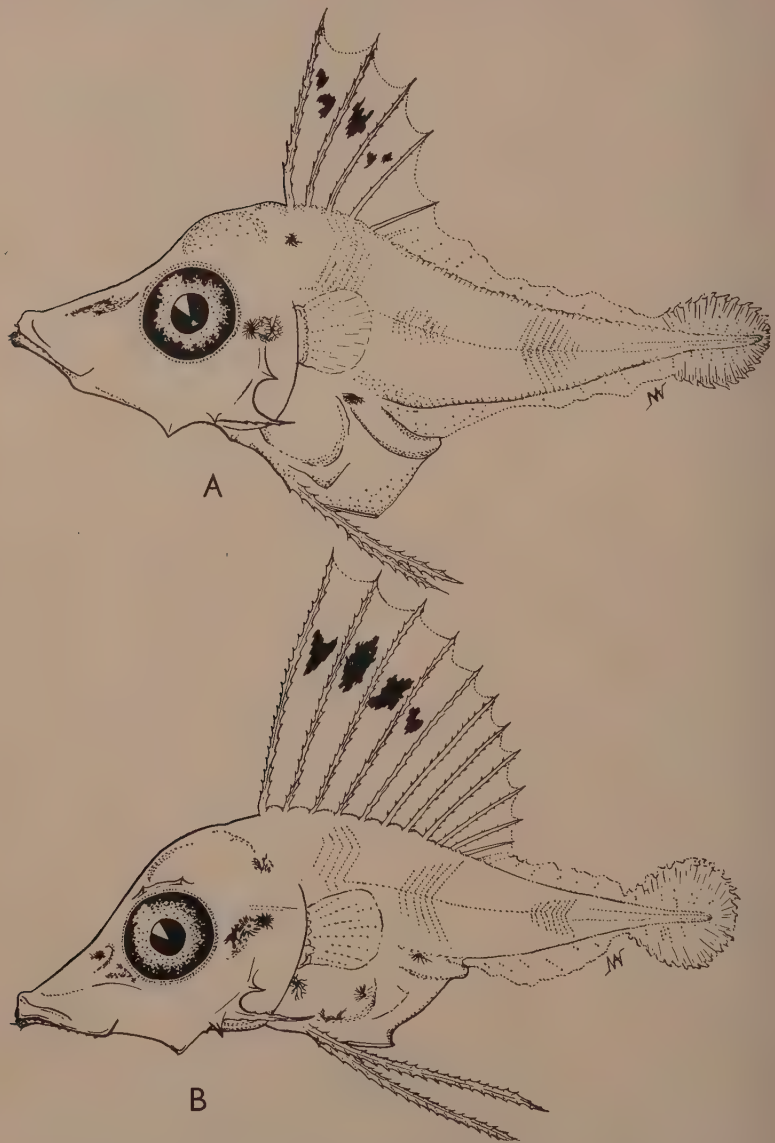

FIGURE 9. *Gempylus* A. Postlarval specimens. A. 4.0 mm standard length; B. 5.3 mm standard length.

line of the caudal fin membrane is ragged but there are no indications of rays. The dorsal and pelvic spines are strongly serrated, but are only of medium length compared to those of the large postlarvae. The characteristic preopercular spine pattern is already evident in the 3.5 mm specimen. In the 4.0 mm specimen, the vertebral column is still straight; the myotome count is indistinct. There are a few large chromatophores on the head and abdominal regions and large dark color spots on the spinous dorsal. Two small teeth project forward from the lower jaw.

In the 4.5 to 5.1 mm specimens, the snout reaches its greatest relative length of about 20 per cent of the standard length. The dorsal spines increase in count, and, in the 5.3 mm specimen (Figure 9B), they number 11. There is still no indication of soft rays. The dorsal spines are at their greatest relative height and the pelvic spines are longer, reaching their maximum relative length at about the 6.0 mm size stage. The characteristic preopercular spine pattern is more pronounced, the second spine being about four times longer than the first. The vertebral column remains straight. A supra-ocular crest is evident. There is an increase of chromatophores on the head and abdominal walls and the color spots on the anterior portion of the spinous dorsal give the appearance of a continuous band of color. The projecting teeth of the lower jaw have enlarged and in this particular specimen are 4 in number.

Over a size range of about 2.2 mm (4.0-6.2 mm specimens), all of the body proportions reach their exaggerated larval peaks (Figure 11). The necessary use of 3 cycle semi-log paper has somewhat sharpened these peaks. The relative depth, and lengths of the head, and dorsal and pelvic spines sharply decrease after this point of postlarval development is reached and the young fish begins its gradual change into the juvenile stage.

Figure 10C of an 8.0 mm specimen shows an early stage of this changeover. The larva is much more elongate in appearance, the urostyle makes its first appearance and the caudal base is developing. There are 22 dorsal spines and indications of soft ray formation in the dorsal, pelvic, pectoral and caudal fins. The number of chromatophores on the head and abdominal walls has increased and there are suggestions of adult pigmentation. The cartilaginous processes of the jaws are beginning to form. A trace of the fangs in the upper and lower jaws was first seen in an 8.1 mm specimen.

By the time that the larva reaches 11.7 mm (Figure 10D), it is well

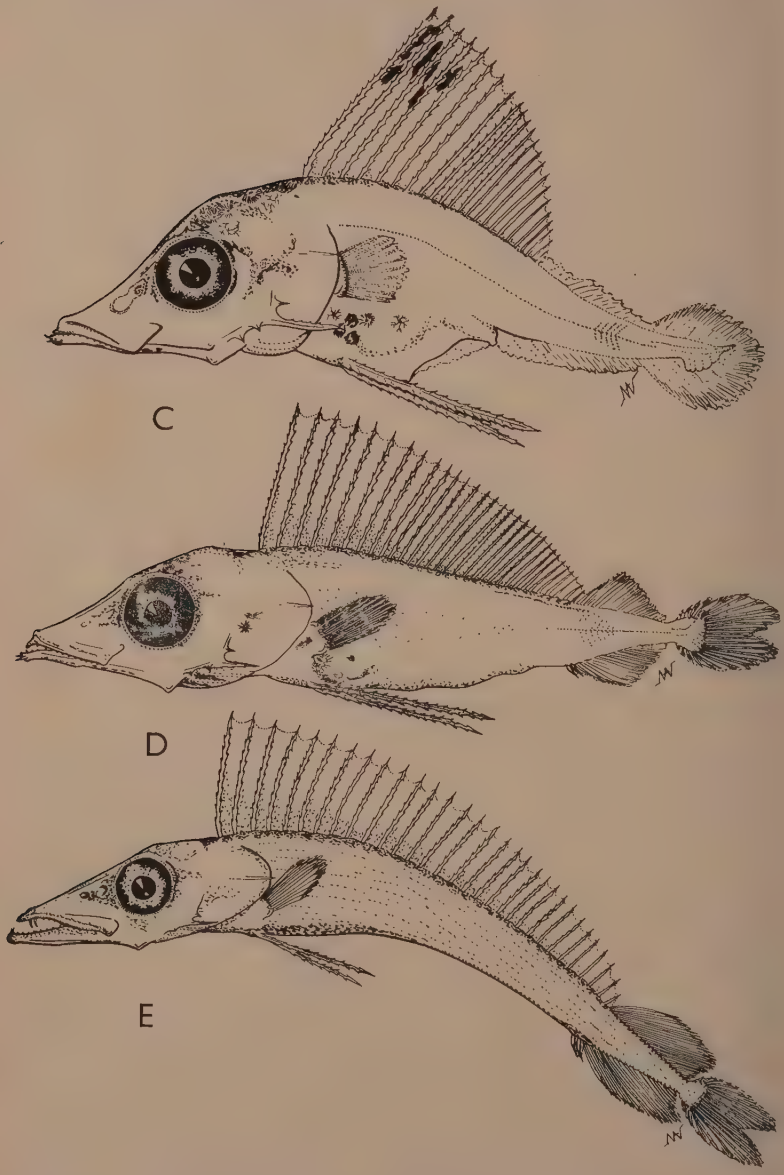

FIGURE 10. *Gempylus* A. Postlarval specimens. C. 8.0 mm standard length; D. 11.7 mm standard length; E. 21.5 mm standard length.

on its way to looking like a juvenile. The head no longer has its larval oversized appearance and the stomach has lost its pouchiness, with the resulting ventral outline being relatively straight and smooth. The spinous dorsal is now assuming the long low look of the adult fin. The dorsal spine count is that of the adult (31) followed by the 23 distinguishable soft rays. There are 2 preanal spines and 17 soft rays in the anal fin. No finlets are evident. The caudal fin is forked and the rays are well developed.

Adult pigmentation predominates. There are only a few large chromatophores remaining on the head and abdominal walls. The jaw processes are fairly well developed, but the fangs are still only faintly evident.

In the 14.3 mm specimen, the soft rays number 30 in the dorsal and 25 in the anal fin. In the 14.2 mm larva, the second preanal spine is about twice as long as the first. In the 14.3 mm larva, 3 preanal spines are present. The fangs are larger, but the projecting teeth, so characteristic of the early post larvae, are still present in the 14.3 mm fish.

The 21.5 mm postlarva closely resembles the adult. The body is relatively long and slim and the spinous dorsal more closely follows its outline than in the previous specimens. The greatest depth is still at the pelvic base and is 14.0 per cent of the standard length. The fin counts in this specimen are: dorsal XXIX, 36; anal II, 26; pelvic I; pectoral 13?. Finlets are not present as yet.

The preopercular spine pattern which characterizes this series of young is present. Up to what size young this pattern is still discernible is not known.

The 82 and 109 mm specimens were in poor condition, both having been taken from the stomachs of dolphin, *Coryphaena hippurus* L. It was impossible to obtain any counts from these two fish. It could not be determined whether or not they belonged to this form of *Gempylus,* but their proportions were plotted in Figure 11 along with those of *Gempylus* A to give the probable slope to the graphs as the postlarvae grow into juveniles.

Food. All of the specimens were examined for stomach contents. In specimens from 4.0 to 11.7 mm, only copepod remains could be distinguished. All identifiable copepods taken from larvae from off Miami were of the genus *Corycaeus,* as was found to be the case in the larvae of *Nesiarchus nasutus.* The 14.3 mm larva from the Central Atlantic had the remains of three copepods and one fish in its stomach. Only

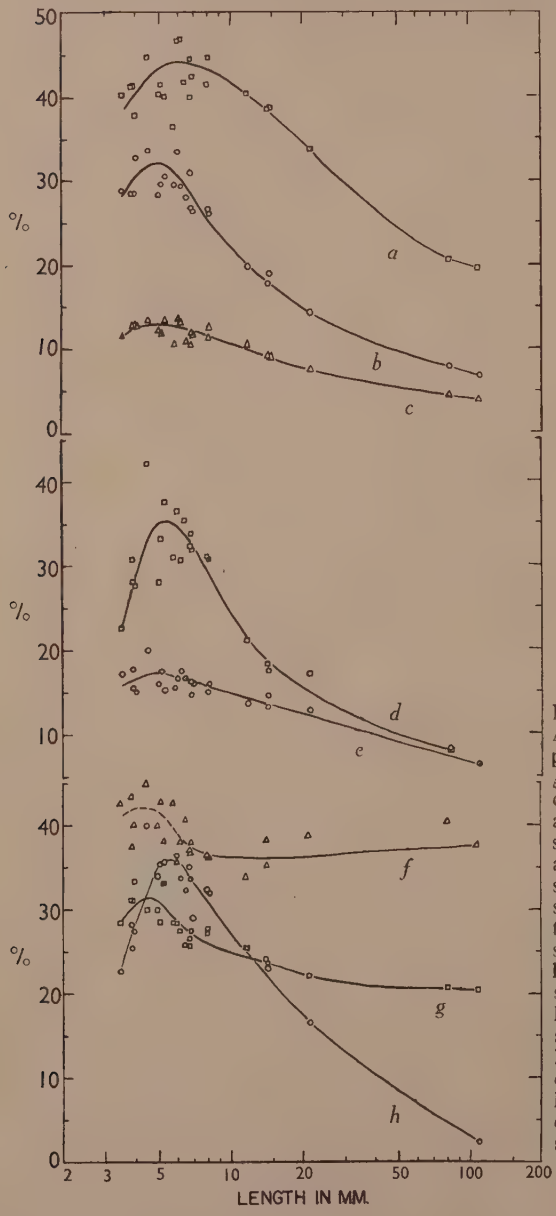

FIGURE 11. *Gempylus* A. Change of bodily proportions during growth. a. Relationship of head length to standard length; b. relationship of depth to standard length; c. relationship of eye diameter to standard length; d. relationship of first dorsal spine length to standard length; e. relationship of snout length to standard length; f. relationship of snout length to head length; g. relationship of eye diameter to head length; h. relationship of pelvic spine length to standard length.

fragments of fish could be discerned from the 82 and 109 mm specimens. Again, the basic larval food appear to be copepods, fish being added to the diet as the larvae increase in size.

Vertical Distribution of the Young. The vertical range of distribution for the postlarvae of *Gempylus* A is nearly twice that found for the postlarvae of *Nesiarchus nasutus.* The larvae of *Gempylus* A were taken from 0 to 347 meters (Figure 12). At the regular NG stations where the depth averages between 150-350 meters, the vertical range for the larvae was 0-243 meters. Five larvae were taken in the upper 50 meters, one was taken at 192 meters and one at 243 meters depth. At the SL stations where the depth averages about 740 meters, the larvae were taken from 150 to 347 meters depth. Two specimens were from 150-200 meters, two from 274 meters and two from 318-347 meters. The fact that the larvae at the SL station are found considerably deeper than at the NG station might be explained by either the increased depth or the greater depth of the isotherms at the SL station.

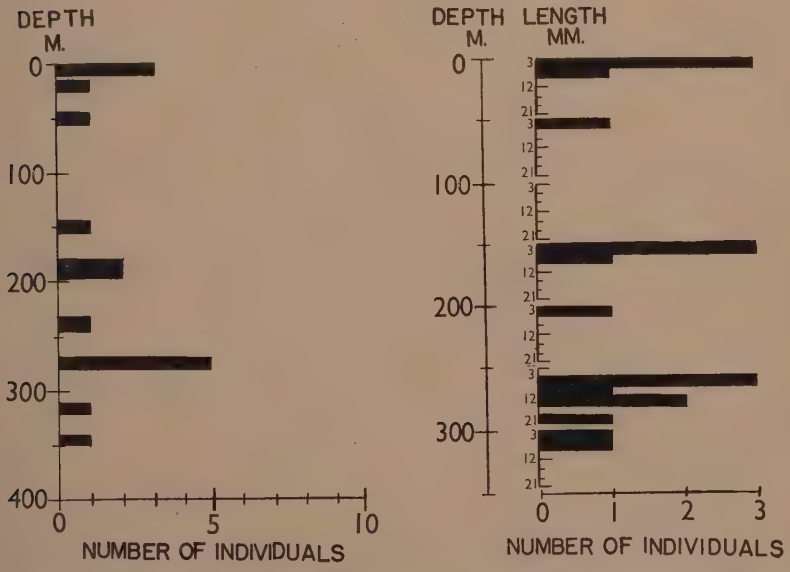

FIGURE 12. *Gempylus* A. Depth distribution of postlarval specimens included in this study.

There appears to be no difference in size range with change of depth, nor does time of day appear to effect the depth at which the larvae are found.

They were taken in waters through a temperature range of 11.7°-24.3°C. and a salinity range of 35.90-36.20 ‰. They occurred over an illumination range of the values 10^{-0}-$10^{-2.0}$. There is no indication that any of these physical factors limit the vertical distribution of the larvae.

Only those specimens taken at the regular NG and SL stations were considered here since there were no accurate depth data on the other material.

Gempylus B

FIGURES 1C; 14.

SPECIMENS STUDIED.

Four specimens (4.4-10.2 mm standard length), from 2 regular NG stations (complete data given in Table 7).

One specimen (6.9 mm standard length), from 1 regular SL station (complete data given in Table 7).

One specimen (11.6 mm standard length), M/V *Theodore N. Gill*, cruise No. 1, station No. 1, February 17, 1953, 0147-0216 hours, 0-17 meters, 27° 00′ N., 79° 18.5′ W.

One specimen (10.9 mm standard length), M/V *Theodore N. Gill*, cruise No. 1, station No. 2, February 17, 1953, 0617-0646 hours, 0-70 meters, 27° 04′ N., 79° 41′ W.

One specimen (5.6 mm standard length), M/V *Theodore N. Gill*, cruise No. 1, station No. 7, February 18, 1953, 0015-0043 hours, 0-70 meters, 27° 40.5′ N., 79° 18′ W.

Spawning. The author has a series of 8 postlarval specimens of the genus *Gempylus* which are taxonomically distinguishable from those just described. These specimens, ranging in size from of 4.4 to 11.6 mm standard length, are referred to here as *Gempylus* B.

Five of the specimens were taken on the east side of the Florida Current off Miami and three were taken in the middle and west side of the Current between Jupiter and Cape Canaveral, Florida (Figure 13). All specimens were taken singly with the exception of one net haul which yielded three larvae.

They occurred off Miami in December, January and June, and, in the waters between Jupiter and Cape Canaveral, in February. Larvae within the range of 4.0-7.0 mm standard length occurred every month in which this form was taken. All were from the upper 70 meters of water. These data reveal the Caribbean area and that of Florida Cur-

rent to be a spawning area for *Gempylus* B. It appears that the adults spawn during the winter months and again in the spring. Additional material may show that the spawning period is a continuous one from winter through spring.

As was the case with the previous two fishes, material is insufficient to determine growth rates.

Development of the Young. The larvae of *Gempylus* B are clearly distinguishable from those of *Gempylus* A throughout the size range

FIGURE 13. *Gempylus* B. Geographic distribution of specimens included in this study.

studied (3.4-21.5 mm standard length). The spinous dorsal is low, for larvae 8.0 mm and under, it is one to two-thirds lower than that of the equivalent size larvae of *Gempylus* A. The pelvic spines are shorter in *Gempylus* B and are followed by soft rays which are lacking in the larvae of *Gempylus* A. The difference in the preopercular spination is immediately noticeable, even in the smallest stages. That of *Gempylus* B has the formula of the length order 1-2-3-4, all spines relatively long and slender, the first and second often upturned (Figure 1C).

The *Gempylus* B larvae under about 5.6 mm standard length are often difficult to distinguish from those of *Nesiarchus nasutus*. At these sizes, the preopercular spination is quite similar and the body proportions fall within the same ranges. The higher dorsal spine count of *Gempylus* B can often be detected, even in these small sizes, and be used as an indication of distinction, but the only positive way that the author has found to separate the two is by a size-series leading down to these smaller larvae from a larger known specimen, which then permits separation by the finer proportional points which lead to the general appearance of the species involved.

All proportions and fin counts for the following specimens are given in Tables 8 and 9. Graphs were not drawn for the relative proportions of this fish because of the insufficient number of specimens.

The larvae of 4.4 and 5.1 mm are deep anteriorly, the depth at the origin of the pelvics 36.4 and 37.3 per cent of the standard length. The larvae quickly lose this exaggerated depth and, by the time the fish has grown to 6.5 mm, the depth is about 23.1 per cent of the standard length. The spinous dorsals of the 4.4, 5.1 and 5.6 mm specimens are low and sloping. In these specimens, the number of dorsal spines increases from 5, to 8 to 14. In the 5.6 mm larva, there are indications of the forming dorsal and anal soft rays. The vertebral column is straight. The pelvic spines are serrated and of medium length, followed, in the 4.4 mm specimen, by one indistinct soft ray, in the 5.6 mm larva, by 2 soft rays.

There are large chromatophores scattered on the head and abdominal walls and, in the 5.6 mm larva, there is a broken color line along the center of the sides. The teeth projecting from the anterior lower jaw are very minute in the two smallest specimens.

In the 6.5 mm, and in the 6.9 mm specimen (Figure 14A), the relative height of the spinous dorsal and length of the pelvic spines are at their greatest. The dorsal spines number 21 to 22. The dorsal and anal

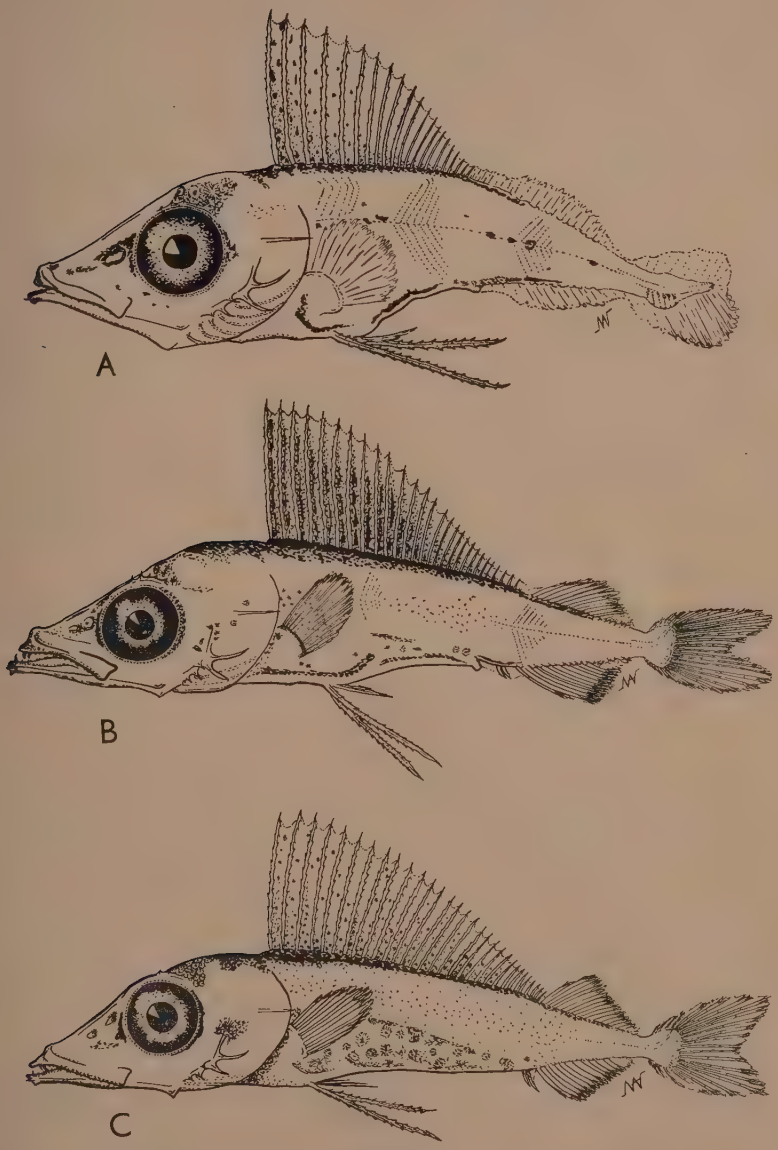

FIGURE 14. *Gempylus* B. Postlarval specimens. A. 6.9 mm standard length; B. 10.2 mm standard length; C. 11.6 mm standard length.

soft rays are not yet well developed. The urostyle first appears here and the caudal base is beginning to form.

There are clear indications of caudal and pectoral rays. The snout at this stage is at its greatest relative length. There is a strong supraocular crest composed of four or five spines.

The adult dark brown pigmentation is prominent on the spinous dorsal and along the dorsal surface of the body. No trace of fangs can be detected.

The 10.2 mm larva (Figure 14B), is beginning to look like a juvenile. It is much slimmer in appearance than at the previous size stages, the depth 21.6 per cent of the standard length. The dorsal spines number 28, followed by 14 well formed soft rays. The two preanal spines are well developed and are followed by 13 soft rays. Three pelvic and 14 pectoral soft rays can be counted. The caudal fin is distinctly forked and the rays are well developed.

There is an increase of the dark brown pigmentation on the dorsal body surface and on the spinous dorsal as well as along the sides of the body. A suggestion of the cartilaginous processes of the jaws are seen in this specimen. The small protruding teeth of the lower jaw are still present and the fangs are evident in both jaws.

Fin development is the most noticeable advancement seen in the 10.9 mm larva over the preceding 10.2 mm fish. The fin elements are: dorsal XXX, 18; anal II, 17; pelvic I, 3; pectoral 13-14?. The second preanal spine is much stouter and twice as long as the first. The second is strongly serrated compared to the first.

Figure 14C of an 11.6 mm specimen illustrates the largest postlarva of *Gempylus* B in the possession of the author. The dorsal and ventral outlines are relatively smooth. The body depth, eye diameter, and the length of the dorsal and pelvic spines are relatively shorter, giving the larva a longer and slimmer appearance. The preopercular spines are shorter. The fin counts for this specimen are: dorsal XXXI, 18; anal II, 13; pelvic I, 3; pectoral 13-14?. The second preanal spine is longer and stouter than the first. The cartilaginous process of the upper jaw is pronounced, but the larval protruding teeth of the lower jaw are retained. The greatest body depth remains at the origin of the pelvics throughout the series.

Food. All of the specimens were dissected for analysis of stomach contents. Only stomachs of the 4.4, 5.6, 6.5 and 10.2 mm larvae yielded recognizable food remains. All of these were copepods. The copepods

from the 4.4, 6.5 and 10.2 mm larvae, all from NG stations off Miami, were of the genus *Corycaeus* except for one small unidentified specimen. There was one copepod in the 4.4 mm larva, three in the 6.5 mm larva and nine in the 10.2 mm larva. The stomach of the 5.6 mm specimen, from off Fort Pierce, Florida, contained one unidentified calanoid copepod. These data again point to the importance of copepods as food for larval marine fishes.

Vertical Distribution of the Young. All specimens of *Gempylus* B were taken in the upper 70 meters of water. The three larvae taken by the M/V *Theodore N. Gill* were from oblique hauls, 70 meters to the surface. Since the waters below 70 meters were not sampled, the depth datum for these three specimens is of little comparative value. On the other hand, the five specimens from the Marine Laboratory stations were taken over a period of three years of monthly stations during which the waters from the surface to the bottom of the area under study were regularly sampled. The resulting data, even for so few specimens, are thus quite significant.

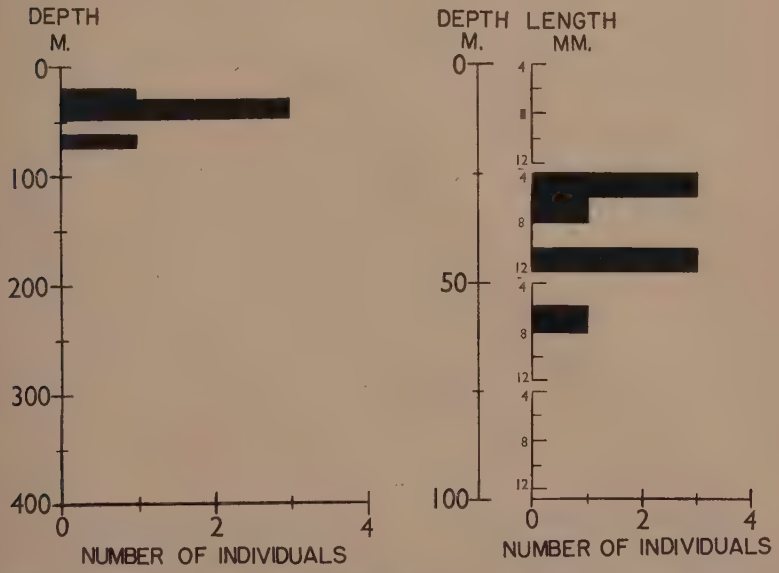

FIGURE 15. *Gempylus* B. Depth distribution of postlarval specimens included in this study.

The larvae were taken from 2245 to 1238 hours in waters ranging in temperature from 23.4°-24.7°C., and salinity from 35.90-36.12 ‰ (Table 7). No illumination data were available and the temperature and salinity data were incomplete.

The vertical distribution of these larvae reveals no indication of diurnal migration. Data on the physical factors of the water are insufficient to show limiting effects, if any, on the vertical range.

As was found with the other gempylids studied, the larvae spend their early postlarval existence in the upper waters taking advantage of the large planktonic food supply.

Discussion

With so little known about the West Indian pelagic fishes, it is not too surprising that our nets have captured so many larvae of a group of fishes usually considered rare. The number of larvae taken to date and reported on in this paper is not sufficient to label the Caribbean area or that of the Florida Current as major spawning grounds for these fishes, but it does indicate the presence of a constant number of breeding and spawning adults. Continued work on the larval fishes of this area is revealing the Florida Current to be an exceptionally rich spawning area in general, and specifically for large numbers of pelagic fishes hitherto considered comparatively rare.

The extensive work of the U. S. Fish and Wildlife Service M/V *Oregon* in the Gulf of Mexico has revealed the presence of only one species of gempylid, *Epinnula orientalis americana* Grey. This same species was the only gempylid taken by the U. S. Fish and Wildlife Service-Gibbs Corporation M/V *Antillas* while doing exploratory fishing in the upper Gulf of Mexico during 1952-1953. The author was unable to find any records of either *Nesiarchus nasutus* or *Gempylus serpens* from the Gulf, but they are recorded from the Caribbean Sea, along the course of the Florida Current and from Bermuda. Voss (1954) reported a similar distribution shown by the squid *Sepioteuthis sepioidea* (Blain.). This distributional pattern, if significant, might be common to many pelagic forms found off our southeastern Atlantic coast. What factor or factors might be limiting this distribution is not known.

It has been generally considered that all described specimens of the genus *Gempylus* belong to the one species *G. serpens* Cuv. and Val. There has been a reasonable amount of doubt concerning this conclusion with the appearance of scattered records of specimens of

Gempylus which were "different". The larval specimens of *Gempylus* reported on in this paper definitely fall into two morphologically distinguishable series which appear to be more than sub-specific in nature. As stated previously, nothing more definite can be concluded until more work is done with the adults and additional material extends the postlarval series into the large juvenile stages.

The postlarval series of *G. serpens* described by Lütken (1880) certainly appear to belong to the genus *Gempylus*. The dorsal and anal soft ray counts, the presence of pelvic soft rays and the illustrations more closely resemble *Gempylus* B than *Gempylus* A. The inadequacy of the descriptions of the young specimens of *G. serpens* reported by Breder (1927) and Longley and Hildebrand (1941) makes it impossible to refer them to one form or the other of this fish.

A comparison of the postlarval development of the three gempylids described in this paper noticeably show *Nesiarchus nasutus* to develop much more rapidly than the two forms of *Gempylus*. In *N. nasutus* the protruding teeth of the lower jaw, so characteristic of the younger gempylid postlarvae, are lost at an earlier stage, and the fins, cartilaginous jaw processes, and fangs develop sooner than in the other two fishes. There appears to be no noticeable difference in the rate of development between the two *Gempylus* forms.

From the overall work with larval fishes of this area, it is quite apparent that many of the larvae from our tropical waters are more highly developed at a smaller size than those of the same species in the northern waters. Thus it may be that the larvae of the fishes just described, when found in the colder waters, will be at a slightly different point of development than that described here at the same size stage.

Summary

1. The fishes belonging to the family Gempylidae and their occurrence in the West Indian area is generally discussed. Previous records of postlarval and juvenile gempylids are given.

2. The materials and methods of collection and study of the postlarvae of three of these fishes from the Florida Current are summarized.

3. The systematic value of general larval characters is discussed. In the family Gempylidae, the relative height of the spinous dorsal, length of the pelvic spines and the preopercular spine pattern were found to be taxonomically valuable in separating the very early postlarvae to species.

4. A series of 30 postlarvae and juveniles of *Nesiarchus nasutus* Johnson, ranging in size from 5.1 to 254 mm standard length, are described and figured. These are the smallest specimens of this species yet recorded and the first time that an adequate size-series has been available for developmental study. Data on spawning, food and vertical distribution are given.

5. Two morphologically distinguishable series of postlarval specimens of the genus *Gempylus* are described and figured. One series of 22 specimens ranges in size from 3.5 to 21.5 mm standard length and the other of 8 specimens from 4.4 to 11.6 mm standard length. Since all adults of this genus have been generally referred to a single species, *G. serpens* Cuv. and Val., the two distinct larval forms, which appear to be more than subspecific in nature, are called *Gempylus* A and *Gempylus* B. Data on spawning, food and vertical distribution are given.

6. Bodily proportions for the fishes are presented in indices and graphs. In each case a peak in postlarval development is sharply defined and in the graphs for *N. nasutus,* where juvenile and adult material was available for comparison, a second developmental peak is evident in the juvenile range.

7. The present study, together with continued work on the larval fishes of this area, has revealed the Florida Current to be an exceptionally rich spawning area for pelagic fishes.

TABLE 1

Nesiarchus nasutus JOHNSON. STATION DATA FOR SPECIMENS STUDIED.

	Station	*Date*	*Location*	*Depth M*	*Time*	*Temp. °C*	*Sal. ‰*	*Illum.*	*No. of Spec.*
NG	32-9	8/14/51	25°43′—26°08′N. 79°56′W.	135	1635	—	—	10^{-2}	1
	32-39	8/15/51	"	135	0810	—	—	10^{-2}	1
	34	10/16/51	"	0-100	1000	25.6	35.96	10^{-2}	8
	35A	10/29/51	"	0	0903	27.4	35.44	10^{-0}	1
	35B	10/29/51	"	37	0903	27.2	36.01	10^{-0}	1
	36A	11/26/51	"	18	1025	26.2	36.10	10^{-0}	1
	38A	1/14/52	"	0	0955	23.5	—	10^{-0}	1
SL	5 F-2	———	———	—	—	—	—	—	1
	8 E-O	10/17/52	25°35′N. 79°25′W.	0	0425	28.1	—	10^{-0}	1
	13 A-0	2/26/53	"	0	1530	23.6	36.09	10^{-0}	1
	14 F-4	3/20/53	"	188	1210	21.8	36.70	10^{-6}	1
	16 A-1	5/22/53	"	55	0310	27.0	36.17	10^{-6}	2
	16 D-0	5/22/53	"	0	2035	27.5	36.06	10^{-4}	1

TABLE 2

Nesiarchus nasutus JOHNSON. FIN COUNTS OF SPECIMENS STUDIED.

Source	*Standard length (in mm.)*	*Dorsal fin*	*Anal fin*	*Pelvic fin*
FR 10	5.1	VI, —	—	I, 1
NG 38A	5.2	XI, —	—	I, 1
SL 13A-0	5.6	VII, —	—	I, 1
NG 36A	6.0	XII, —	—	I, 3
SL 8E-0	6.0	XII, —	—	I, 2
SL 16D-0	6.0	XII, —	—	I, 1
NG 34	6.2	XIII, —	—	I, 3
NG 35B	6.9	XIV, —	—	I, 3-4
NG 32-9	7.0	XVI, —	—	I, 3-4
SL 14F-4	7.0	XV, —	—	I, 2
Gill 31, Cr. 3	7.2	XVI, 8	—	I, 2
USNM 153677	7.2	XXI?,—	—	I, ?
Gill 31, Cr. 3	7.4	XIX, 12	11	I, 2
SL 5F-2	7.5	XX, 15	16	I, 4
NG 34	7.5	XIX, —	—	I, 4
NG 35A	8.0	XXI, 17	18	I, 4
Gill 31, Cr. 3	8.7	XIX, 14	—	I, 3-4
NG 34	9.3	XXI, 17	II, 17	I, 4
NG 32-39	10.0	XX, 13	II, 17	I, 4
NG 34	10.8	XXI, 18	II, 10	I, 4
NG 34	11.3	XXI, 21	II, 20	I, 4
NG 34	11.7	XXI, 20	II, 17	I, 4
SL 16A-1	13.4	XXI, 19	II, 20	I, 4
NG 34	14.0	XXI, 20	II, 20	I, 4
SL 16A-1	16.7	XXI, 22	II, 18	I, 4
NG 34	17.5	XX, 23	II, 22	I, 4
USNM 153677	23.5	XX?, 21?	II, 13	I, 4-5
Yara 39	188.0	XXI, 20, 2	II, 20, 2	I, 4
USNM 151899	225.0	XXI, 21, 2	II, 11, 2	I, 4
USNM 151899	254.0	XXI, 20, 2	II, 18, 2	I, 4

TABLE 3
Nesiarchus nasutus JOHNSON. BODILY PROPORTIONS OF SPECIMENS STUDIED.

Source	*Std. L. mm.*	*Depth Index*	*Head Index*	*Snout Index*	*Snout Head Index*	*Eye Index*	*Eye Head Index*	*Pelvic Spine Index*	*Dorsal Spine Index*
FR 10	5.1	23.5	33.4	11.8	35.2	9.8	29.4	9.8	11.8
NG 38A	5.2	28.9	36.6	13.5	36.8	11.5	31.5	17.3	17.3
SL 13A-0	5.6	23.2	37.5	14.3	38.1	10.7	28.6	7.2	—
NG 36A	6.0	23.3	38.3	13.3	34.8	11.7	30.4	15.0	16.7
SL 8E-0	6.0	23.2	40.0	16.7	41.7	13.3	33.3	18.3	—
SL 16D-0	6.0	26.7	41.7	16.7	40.0	13.3	32.0	15.0	15.0
NG 34	6.2	29.1	48.4	21.0	43.4	16.1	33.4	21.0	—
NG 35B	6.9	26.1	46.4	16.0	34.4	13.0	28.1	18.8	14.5
NG 32-9	7.0	24.3	44.3	18.6	42.0	12.9	29.0	—	—
SL 14F-4	7.0	27.1	45.7	17.2	37.5	14.3	31.3	17.1	14.3
Gill 31, Cr. 3	7.2	25.0	44.5	18.1	40.6	12.5	28.1	16.7	—
USNM 153677	7.2	25.0	44.5	18.1	40.7	12.5	28.1	—	—
Gill 31, Cr. 3	7.4	24.4	46.0	20.3	44.2	13.5	29.4	24.4	—
SL 5F-2	7.5	25.4	49.4	21.4	43.2	13.3	27.0	22.6	17.3
NG 34	7.5	26.7	50.7	24.0	47.3	13.7	26.3	25.4	—
NG 35A	8.0	25.0	51.2	22.5	44.0	13.8	26.8	26.2	—
Gill 31, Cr. 3	8.7	23.0	48.2	20.7	42.8	12.7	26.2	—	18.4
NG 34	9.3	23.7	47.4	22.6	47.0	10.8	20.4	24.7	16.1
NG 32-39	10.0	21.0	49.0	23.0	47.0	11.0	22.5	27.0	18.0
NG 34	10.8	21.1	47.2	21.3	45.2	9.3	19.6	27.8	—
NG 34	11.3	24.8	51.4	22.1	43.1	11.5	22.4	29.2	17.7
NG 34	11.7	23.1	49.5	24.8	50.0	9.4	19.0	25.6	18.0
SL 16A-1	13.4	22.4	46.3	22.4	48.4	9.7	21.0	22.4	17.9
NG 34	14.0	22.2	48.5	22.8	47.0	9.3	19.1	25.0	18.6
SL 16A-1	16.7	19.8	46.1	23.4	50.7	9.0	19.5	20.4	—
NG 34	17.5	19.4	44.0	22.3	50.7	9.7	22.0	19.4	16.0
USNM 153677	23.5	14.0	38.7	18.7	48.4	6.8	17.6	—	—
Yara 39	188.0	8.7	27.1	13.6	48.6	4.3	15.2	3.7	4.8
USNM 151899	225.0	9.8	28.5	14.7	53.0	3.9	13.7	4.4	4.5
USNM 151899	254.0	11.8	29.3	14.5	49.4	4.0	13.7	4.0	4.1
*	287.0	—	31.4	14.6	47.0	4.0	12.8	4.5	—
*	295.0	—	32.4	14.9	47.0	4.2	13.3	4.1	—
*	388.0	—	27.5	12.6	45.0	3.5	12.7	5.1	—
*	481.0	—	28.6	12.9	45.0	3.9	13.8	3.1	—
*	572.5	—	24.7	10.8	43.4	3.1	12.7	2.8	—
*	737.0	—	24.6	11.2	45.4	3.2	12.9	2.6	—
**USNM 39287	1115.0	11.3	25.1	10.5	41.8	3.3	13.2	—	—

* Bermuda specimens, M. Grey, 1953: 156.
**Type specimen, Goode and Bean, 1895: 195.

TABLE 4

Gempylus A. Station Data for Specimens Studied.

Station	Date	Location	Depth M	Time	Temp. °C.	Sal. ‰	Illum.	No. of Spec.
NG 11E-2	12/10/50	24°03.5′N. 82°04.1′W.	182	0650	14.4	35.90	—	1
16-25	1/29/51	25°46′-25°51′N. 79°49′W.	16	0447	24.3	36.20	10^{-6}	1
16-34	1/29/51	"	192	0910	11.7	35.90	10^{-8}	1
17A	1/29/51	25°48′N.,79°34′W.	0	1920	—	—	—	2
19A	1/30/51	25°35′N.,79°23′W.	0	0321	—	—	10^{-0}	1
32-6	8/14/51	25°43′-26°08′N. 79°56′W.	243	1140	—	—	10^{-4}	1
39B	2/ 4/52	"	50	1050	23.4	36.16	—	1
SL 13B-4	2/26/53	25°35′N. 79°25′W.	182	2100	22.9	—	10^{-16}	1
13E-2	2/27/53	"	149	0750	23.3	—	10^{-10}	1
16A-4	5/22/53	"	347	0415	18.5	—	10^{-20}	1
16C-4	5/22/53	"	318	1655	19.1	—	10^{-14}	1
19C-3	8/14/53	"	247	0235	—	—	—	2

TABLE 5

Gempylus A. Fin Counts of Specimens Studied.

Source	Standard length (in mm.)	Dorsal fin	Anal fin	Pelvic fin
NG 19A	3.5	IV, —	—	I
SL 16C-4	3.9	VI, —	—	I
NG 16-34	3.9	IV, —	—	I
NG 39B	4.0	V, —	—	I
NG 11E-2	4.2	VI, —	—	I
USNM 163353	4.5	VIII, —	—	I
NG 17A	5.0	IX, —	—	I
NG 32-6	5.1	IX, —	—	I
SL 13B-4	5.3	XI, —	—	I
NG 17A	5.8	X, —	—	I
USNM 163352	6.0	XIV, —	—	I
SL 19C-3	6.2	XVIII, —	—	I
USNM 163353	6.5	XIV, —	—	I
NG 16-25	6.8	XXI, —	—	I
USNM 163349	6.8	XIV, —	—	I
SL 10 C-3	6.9	XXI, —	—	I
SL 13E-2	8.0	XXII, —	—	I
SL 16A-4	8.1	XXV, —	—	I
USNM 113291	11.7	XXXII, 23	II, 17	I
USNM 163349	14.2	XXXI, 23	II, 18—	I
USNM 113291	14.3	XXXII, 30	III, 25	I
USNM 113291	21.5	XXXI, 36	II, 26	I

TABLE 6
Gempylus A. Bodily Proportions of Specimens Studied.

Source	*Std. L. mm.*	*Depth Index*	*Head Index*	*Snout Index*	*Snout Head Index*	*Eye Index*	*Eye Head Index*	*Pelvic Spine Index*	*Dorsal Spine Index*
NG 19A	3.5	28.6	40.0	17.2	42.8	11.4	28.6	22.8	22.8
SL 16C-4	3.9	28.2	41.0	17.9	43.7	12.8	31.2	25.6	28.2
NG 16-34	3.9	28.2	41.0	15.4	37.5	12.8	31.2	28.2	30.8
NG 39B	4.0	32.6	37.5	15.0	40.0	12.5	33.4	27.5	27.6
NG 11E-2	4.2	26.2	38.1	16.7	43.8	11.9	31.1	26.2	28.6
USNM 163353	4.5	33.4	44.5	20.0	45.0	13.3	30.0	40.0	42.2
NG 17A	5.0	28.0	40.0	16.0	40.0	12.0	30.0	34.0	28.0
NG 32-6	5.1	29.4	41.2	17.6	42.8	11.8	28.6	35.3	33.4
SL 13B-4	5.3	30.2	39.6	15.1	38.1	13.2	33.3	35.8	37.8
NG 17A	5.8	29.3	36.2	15.5	42.8	10.3	28.6	—	31.0
USNM 163352	6.0	33.4	46.7	16.7	35.8	13.3	28.6	36.6	36.6
SL 19C-3	6.2	29.0	46.8	17.7	38.0	12.9	27.6	33.9	30.7
USNM 163353	6.5	27.7	41.5	16.9	40.8	10.8	25.9	32.3	35.4
NG 16-25	6.8	30.9	39.8	14.7	37.1	10.3	25.9	35.2	33.8
USNM 163349	6.8	26.5	44.1	16.2	36.7	11.8	26.6	33.8	32.4
SL 19C-3	6.9	26.1	42.1	16.0	38.0	11.6	27.6	29.0	31.9
SL 13E-2	8.0	26.3	41.2	15.0	36.4	11.2	27.2	32.5	31.2
SL 16A-4	8.1	26.0	44.4	16.1	36.1	12.3	27.8	32.1	30.9
USNM 113291	11.7	19.7	40.2	13.7	34.0	10.3	25.6	25.6	21.2
USNM 163349	14.2	17.6	38.0	13.4	35.2	9.2	24.1	—	18.3
USNM 113291	14.3	18.9	38.5	14.7	38.2	9.1	23.7	23.1	17.5
USNM 113291	21.5	14.0	33.5	13.0	38.9	7.5	22.2	16.8	17.2
J. K. Howard	82.0	7.9	20.5	8.3	40.5	4.3	20.8	—	8.2
Gill Cr. 2, Sp.	109.0	6.5	19.3	7.3	37.6	3.9	20.5	2.4	—

TABLE 7
Gempylus B. Station Data for Specimens Studied.

Station	*Date*	*Location*	*Depth M*	*Time*	*Temp. °C*	*Sal. °/00*	*Illum.*	*No. of Spec.*
NG 26A	6/5/51	25°43′— 26°08′N. 79°56′W.	25	1020	24.7	35.90	—	1
38F	1/14/52	"	46	1238	23.4	36.12	—	3
SL 10C-3	12/9/52	"	69	2245	—	—	—	1

TABLE 8
Gempylus B. Fin Counts of Specimens Studied.

Source	Standard length (in mm.)	Dorsal fin	Anal fin	Pelvic fin
NG 38F	4.4	V, —	—	I, 1
NG 38F	5.1	VIII, —	—	I, 1
Gill 3, Cr. 1	5.6	XIV, —	—	I, 2
NG 26A	6.5	XXII, —	—	I, 2
SL 10C-3	6.9	XXI, —	—	I, 2-3
NG 38F	10.2	XXVIII, 14	II, 13	I, 3
Gill 2, Cr. 1	10.9	XXX, 18	II, 17	I, 3
Gill 1, Cr. 1	11.6	XXXI, 18	II, 13	I, 3

TABLE 9
Gempylus B. Bodily Proportions of Specimens Studied.

Source	Std. L. mm.	Depth Index	Head Index	Snout Index	Snout Head Index	Eye Index	Eye Head Index	Pelvic Spine Index	Dorsal Spine Index
NG 38F	4.4	36.4	36.4	13.6	37.5	13.6	37.5	13.6	6.8
NG 38F	5.1	37.3	39.2	15.7	40.0	13.7	35.0	15.7	11.8
Gill 7, Cr. 1	5.6	25.0	37.5	12.5	33.4	12.5	33.4	17.9	19.7
NG 26A	6.5	23.1	41.6	15.4	37.0	13.9	33.3	27.7	24.6
SL 10C-3	6.9	24.3	39.2	14.5	37.1	11.6	29.6	26.1	21.8
NG 38F	10.2	21.6	40.2	12.7	32.5	11.8	29.3	21.6	21.6
Gill 2, Cr. 1	10.9	19.3	35.8	11.9	33.4	11.0	30.8	22.9	20.2
Gill 1, Cr. 1	11.6	19.8	37.9	13.8	36.4	10.3	27.4	21.6	20.7

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The scope of the bibliography is limited in general to the area which includes the southeastern United States, the Gulf of Mexico, and the Caribbean, but papers of more general interest may be listed in cases where they have some special significance to the area.

The degree of comprehensiveness of the bibliography is to a large extent dependent upon the cooperation of workers in the Marine Sciences of this area. *It is therefore hoped that individuals and organizations will aid by sending copies of all relevant publications to the Editor.* Any omissions brought to the attention of the Editor will be included in subsequent issues.

It has been found convenient to use a modification of the classification used by the Journal du Conseil Bibliography for present purposes.

The Editorial staff wishes to acknowledge the valuable assistance given by a number of investigators in compiling the bibliography.

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Instructions for Preparation of Manuscripts

CONTRIBUTIONS will be considered which deal with research in the marine sciences, directly or indirectly related to the southeastern United States and the Caribbean area. Papers dealing solely with the economic or applied aspects of commercial fisheries will not be accepted.

Manuscripts may be submitted in languages other than English but publication will be in English only. Where possible, arrangements will be made for translation.

All copy should be typewritten and double spaced. Footnotes should be avoided as far as possible. If used they should be numbered continuously throughout the paper and set off in the body of the text.

Bibliographical references must be indicated by author's name and year of publication. References should be listed under that heading in alphabetical order of authors. Each reference should include the last name followed by initials or the first name. Co-authors should be listed with initials preceding the last name. The date should appear next to the author's name, followed by a complete title, in lower case except for the first word. The publisher, city and pagination should follow, in the case of books. The names of periodicals should be abbreviated as in "World List of Scientific Periodicals," Oxford. The volume is then given in arabic numerals underlined for italics, followed by the number in brackets and the pagination preceded by a colon. After the first line of each reference the copy is indented.

Figures must be submitted with the manuscript, either as originals or photographs. Half-tone reproductions should be avoided where possible. Large numbers of tables or illustrations will usually be accepted only if arrangements are made by the author or his institution to contribute towards the cost. The proper size of lines, characters and symbols must be used and illustrations must be of such a size that they may be reduced by at least 2/3. Mechanical lettering should be employed. Alternatively, lettering may be indicated on a translucent paper cover, for setting by the editorial office. Tables should be simple and with a minimum of rulings. Legends should be typed on a separate sheet with proper identification by illustration number at the end of the manuscript. A brief abstract should accompany each contribution.

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